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Evaluation of Window Guards for Resistance to Forced Entry

Research Report

August 1983

Canada

Canada Mortgage and Housing Corporation, the Federal Government's housing agency, is responsible for administering the National Housing Act.

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Evaluation of Window Guards for Resistance to Forced Entry

Prepared for

The Project Implementation Division

Policy Development and Research Sector

Canada Mortgage and Housing Corporation

by

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The principal objective of this test series was to determine the performance of window guards from a physical security point of view. This study was conducted by Forintek Canada Corp. for Canada Mortgage and Housing Corporation under Part V of the National Housing Act. The analysis, interpretations, and recommendations are those of the consultants and do not necessarily reflect the views of Canada Mortgage and Housing Corporation.

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EXECUTIVE SUMMARY

A total of nineteen pairs of basement window guards were evaluated during the course of the study.

The test data indicated that 8 of the 13 commercial guards evaluated, reached the point of failure, at loads of 4.4 kN (1000 lbs) or less.

The data also showed that the home-made guard, built with water pipes, was more resistant to forcible entry, than 69% (9) of the commercial guards tested, while the RCMP window guards generally proved to be the most resistant guards.

The study also confirmed the need to conduct additional testing on fasteners, as well as to determine the resistance of the guards and various types of padlocks, to cutting or sawing.

TERMINOLOGY AND ABBREVIATIONS

CMHC	Canada Mortgage and Housing Corporation
mm	millimetre
N	newton
kN	kilo-newton
lbf	pound force
lbs	pounds mass
RCMP	Royal Canadian Mounted Police

RESEARCH METHODOLOGY AND ASSUMPTIONS

Because basement windows are frequently the target of burglary attacks, the Project Implementation Division of Canada Mortgage and Housing Corporation contracted Forintek Canada Corp. Eastern Laboratory to test and evaluate eighteen* sets of basement window guards for resistance to forcible entry (Contract No. 55-68-842). After several meetings involving CMHC, Forintek and Police Force representatives, the following procedures were agreed to:

- Two tests will be conducted on each type of window guard. Generally the first test will be a straight push at the weakest point of the window guard while it is securely mounted in the center of a window frame. Secondly, a spreading test will be conducted on two points within the window guard.
- Fasteners and frames will be strong enough so that test results reflect the performance of the window guards only.
- The research program will be split into two phases; pre-test and test.
- The preliminary tests will be carried out to the point of failure, or up to a maximum load of 26.69 kN (6000 lbf). The maximum limit was selected on the basis that small portable scissor-jacks or crowbars, occasionally used in break-in situation, can generate forces of this magnitude.

* One set of window guard was added as the study was in progress.

- Window guards will be considered as having failed (pre-test) when the opening between bars reaches 203 mm x 406 mm (8 in. x 16 in.) (estimated opening size required for a child or a small man to gain entry).
- The final report will include the same type of information found in previous CMHC security reports.

However, following the preliminary tests and the early stages of the actual testing, it became apparent that certain changes had to be made before testing could be resumed.

The following modifications were agreed to:

- The maximum limit for the straight push test will be changed from 26.69 kN (6000 lbf) to 17.79 kN (4000 lbf); mainly because the wooden window frames will fail before the guards. This force represents the maximum capacity of small (portable) ratchet-hoist pullers that can be purchased in any hardware store.
- Secondly the opening size determining the point of failure will be reduced from 203 mm x 406 mm (8 in. x 16 in.) to 191 mm x 305 mm (7½ in. x 12 in.), because records show that the latter size is adequate to gain entry.
- All guards will be tested to failure or up to the maximum limits set for the straight push test and the bar separation test.

This report contains the results of these evaluations and recommendations for future work.

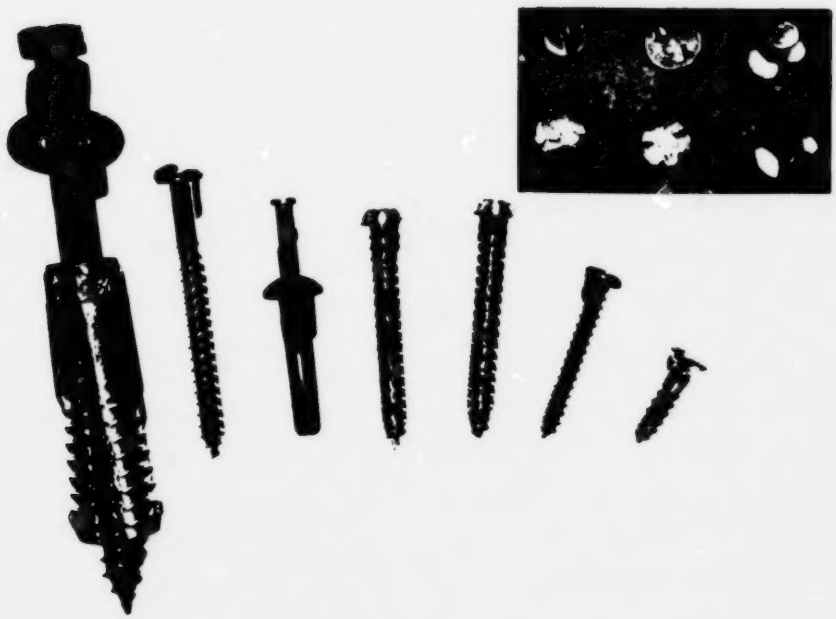


FIGURE 1. Various Types of Fasteners Currently Used for Installing Window Guards (concrete fastener to left, and six examples of tamper-resistant heads, to right).

MATERIALS

Window Guards

Nineteen sets of window guards (including the set used for preliminary testing) were evaluated during the course of the study. The selection included thirteen pairs of commercial guards of varied quality (samples 1-13), five sets of guards designed and constructed by the Royal Canadian Mounted Police security laboratory (Samples 14-18), and one home-made model, built with water pipes, as suggested by the Nepean and Ottawa Police Force. The window guards were mounted in the center of the window frames for testing.

Each window guard is described in detail before each individual test.

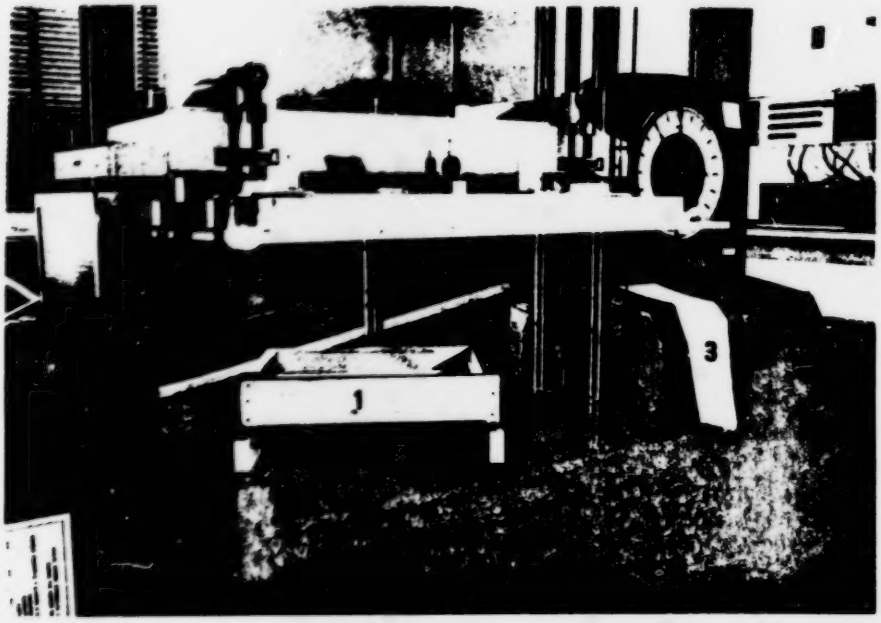
Window Frames

The window frames were built extra strong, with lumber that was 35 mm (1 3/8 in.) thick and 127 mm (5 in.) wide, to ensure that the tests reflected the performance of the window guards only.

Fasteners

Many types of fasteners such as one-way screws, lag-bolts, rivets, screws with tamper-resistant heads, and concrete fasteners are commonly used for the installation of window guards (Figure 1). The quality of these fasterners varies greatly and some such as rivets and short screws should not be used at all.

For this reason all window guards were mounted with 6.35 mm diameter (¼ in.) machine bolts that extended beyond the outer part of the stile. Washers were also used to prevent the nuts from digging into the wood. (A few hinged guards were installed with screws because of space limitations).



1) Window frame with guard mounted

2) Load applicator

3) Load-deformation recording chart

FIGURE 2. Set-up for Straight Push Test

METHODS

Test No. 1. "Straight Push Test"

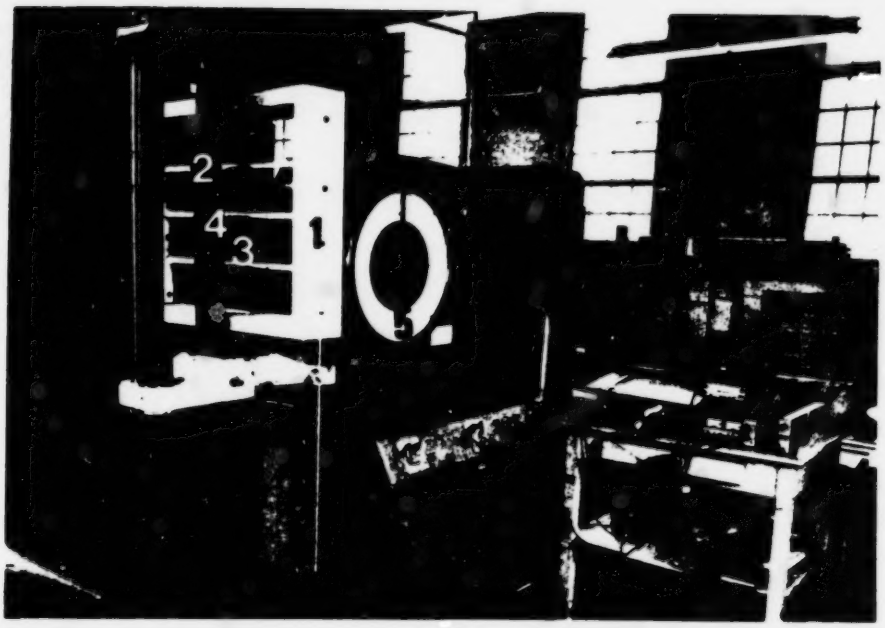
The specimens were tested in a Rhiele compression tester having a maximum load capacity of 89 kN (20,000 lbf) according to the following procedure:

Each specimen was placed on the bottom platform of the compression machine; a 59 mm (2.3 in.) diameter steel rod was fixed to the center of the top platen to act as a load applicator. The top platen was lowered until the steel rod came in contact with the weakest point of the window guard (arbitrarily selected). The load-deformation recording chart was then zeroed, and a load was applied through a uniform motion of the top platen at a speed of 8 mm/min. (.3 in./min.). The test set-up is shown in Figure 2.

Test No. 2. "Bar Separation Test ("Spreading)"

The second set of window guards was subjected to a bar separation test in a Rhiele testing machine, having a maximum load capacity of 178 kN (40,000 lbf) according to the following procedure.

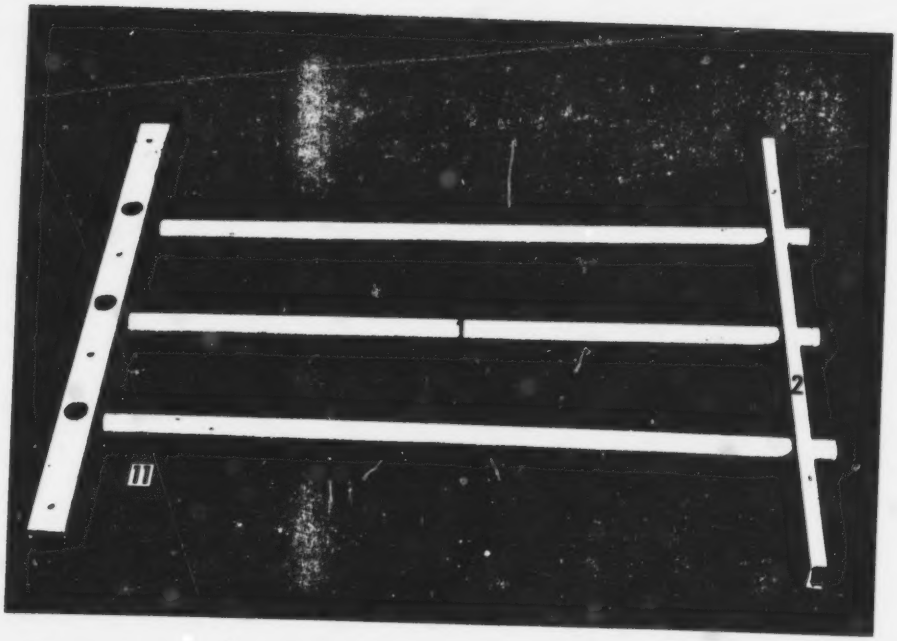
A strong metal bracket wide enough to receive the window frames, was anchored to the base of the testing machine. Each window frame was inserted into this bottom bracket, in its normal position. The lower bar of each window guard was held down by a 29-mm (1 1/8 in.) diameter steel rod; this restraining rod was locked onto the bracket with a strong cotter pin, to prevent slippage during test. A similar bracket (adjustable) having the load applicator rod located on the interior part of an adjacent



1) Window frame with guard mounted
2) Brackets
3) Restraining rod
4) Load applicator rod
5) Load recorder

FIGURE 3. Set-up for Bar Separation Test

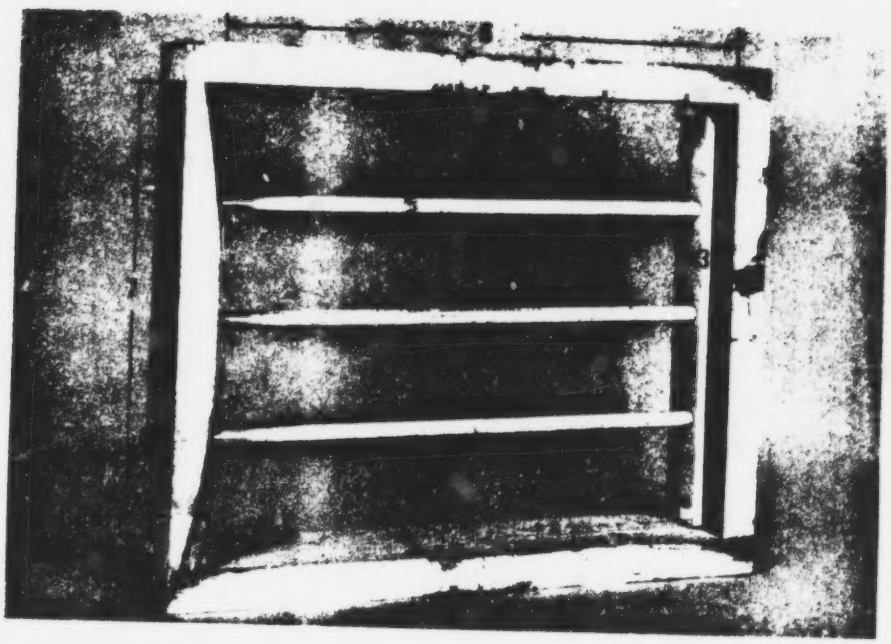
bar of the guard, was fastened to the moveable head of the testing machine. A load was then applied between the two bars of the window guard with a uniform motion of the moveable head at a speed of 8-mm/min. (.3-in./min.). Figure 3 shows the bar separation test set-up.



1) 19 mm ($\frac{3}{4}$ in.) diameter solid steel rods

2) 38 mm x 13 mm ($1\frac{1}{2}$ in. x $\frac{1}{2}$ in.) U-channel

FIGURE 4. Window Guard Components



3) 6.35 mm ($\frac{1}{4}$ in.) machine bolts; screws were also used.

4) 111 mm (4 3/8 in.) bar separation

5) 120 mm $4\frac{3}{4}$ in.)

6) 514 mm ($20\frac{1}{4}$ in.)

7) 623 mm ($24\frac{1}{2}$ in.)

FIGURE 5. Window Guard Before Test

Pre-Test

Materials and Design

Window guard #11 is a fixed guard consisting of three 19 mm ($\frac{3}{4}$-in.) diameter horizontal solid steel rods, fitted into two vertical steel channels attached to the stiles of the window frame. The channels of specimen No. 11A are fastened with 25-mm (1-in.) No. 10 wood screws, while those of specimens 11B and 11C are fastened with 6.35 mm ($\frac{1}{4}$-in.) diameter machine bolts. The straight push test was conducted on specimens 11A and 11B, while specimen 11C was subjected to the bar spreading (separation) test. Window guard #11 is shown in Figures 4 and 5.

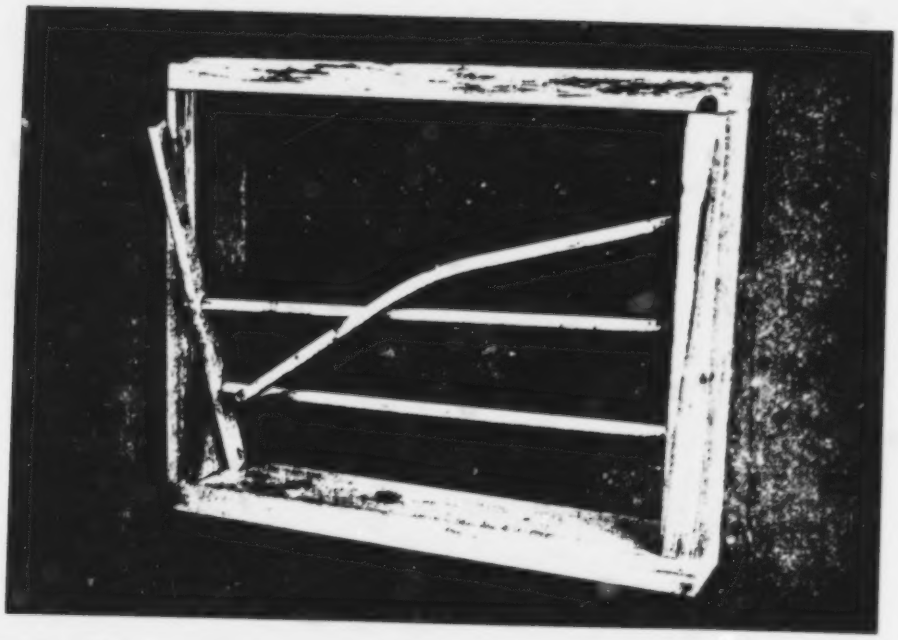


FIGURE 6. Specimen No. 11A After the Straight Push Test

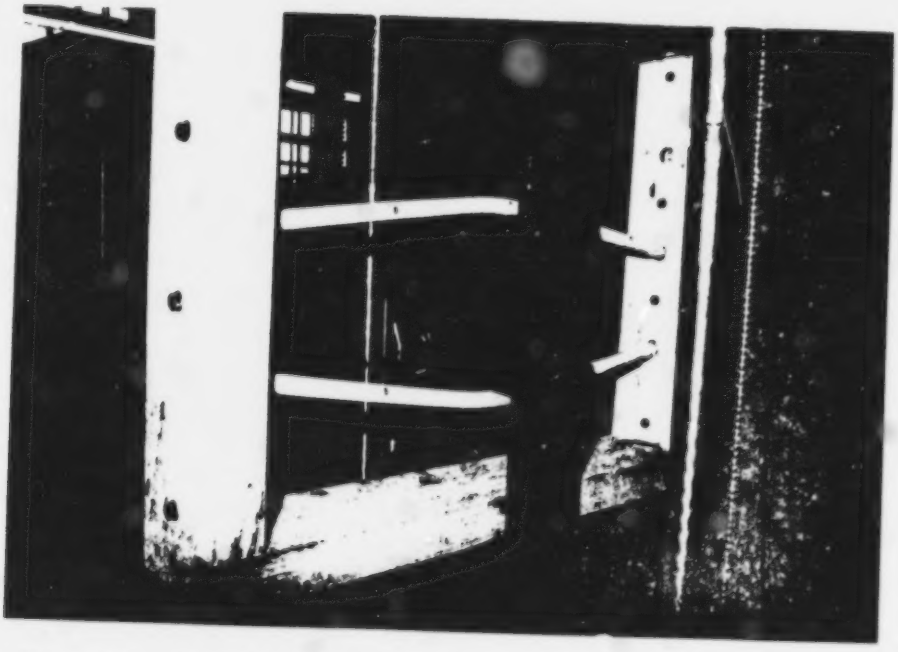


FIGURE 7. Specimen No. 11C During Bar Separation Test

TEST RESULTS (Pre-test)

The results of the straight push test carried out by applying a load at the center of the top window bar (Sample 11A, fastened with screws) indicated that a 2,890 N (650 lbf) load was sufficient to cause simultaneous failure of the window bar (bent to a point where one end slid from the channel) and the fasteners (one channel was pushed from the stile). Figure 6 , shows sample 11A following test.

The same test conducted on Specimen No. 11B (installed with 6.35 mm bolts) showed that the window bar had to be bent 88 mm in the center before releasing from the channels. A 3,150 N (708 lbf) load was required to dislodge the bar creating an opening large enough (245 mm x 600 mm or 9 5/8 in. x 23 5/8 in.) to allow entry to be gained.

The bar separation test was conducted on Specimen No. 11C (fastened with 6.35 mm ($\frac{1}{4}$-in) bolts.

The test results indicated that maximum load was reached at 2,750 N (618 lbf). The test was discontinued before the bar could slip from the channel (total spread 150 mm (5 7/8 in.) to measure the recovery (Figure 7). The bars sprung back 13 mm ($\frac{1}{2}$-in.) after the load was removed.

In addition to the normal tests, the force that could be generated using a crowbar and a wooden block, by applying a load between the platens of a compression tester, was also measured.

The test showed that even a small man weighing approximately 68.2 kg (150 lbs) can apply loads of well over 22.2 kN (5000 lbf).

Detailed test data are shown in Tables 1 and 2.

CONCLUSION (Pre-test)

The straight push test data demonstrated the importance of using proper fasteners for testing.

The test data also showed that a load of 3,150 N (708 lbf) was required to gain entry through a properly fastened guard, using the straight push test method while a spreading force of 2,750 N (618 lbf) was sufficient, using the bar separation method.

Such forces can easily be generated using a short lever, such as a crowbar, in conjuction with a small wood block.

RECOMMENDATION (Pre-test)

The evaluation of the remaining 18 window guards should be carried out using basically the same testing procedure.

However, the opening size determining the point of failure should be reduced from 203 mm x 406 mm (8 in. x 16 in.) to 191 mm x 305 mm (7½ in. x 12 in.). These dimensions were selected after measuring several small persons.

RESULTS AND DISCUSSION

Out of the nineteen window guards evaluated by the straight push method and the bar separation method, only three were not tested to failure (guards #4, 16 and 17). The design of guard #4 was so complicated that the push test was discontinued after applying three loads without success; the spreading test was also stopped after one of the horizontal bars came in contact with the frame. The bar separation test conducted on guard #16 was also discontinued after the application of a spreading force of 25,690 N (5685 lbf), because of a window frame failure. Guard #17 was tested up to the maximum limits, set for both tests.

The test data also showed that nine guards failed one of the two tests at loads of 4.4 kN (1000 lbf) or less, while fifteen out of the nineteen guards tested, failed to sustain loads of more than 8.9 kN (2000 lbf). It was generally easier to break-in through the window guards by spreading the bars, (62.5% of the cases) than by pushing against them.

The window guards designed and constructed by the RCMP's Security Engineering Branch (guards 14-18) were generally stronger than the commercial guards tested. In fact two of the five guards exceeded the prescribed maximum testing limits, (#16 and #17) while a third guard (#18) failed during the straight push test at 11,076 N (2490 lbf), after two load applications. Guard #15 was the only guard produced by the RCMP that did not do very well and it failed at 2340 N or 526 lbs.

Eight of the thirteen commercial guards failed at loads of 4.4 kN (1000 lbs) or less (#2, #5, #6, #7, #8, #9, #10 and #11). In fact the home-made window guard, built with water pipes (#19) was more resistant to forcible entry than nine of the commercial guards and two of the RCMP guards.

The design of the window guard appears to be of prime importance as demonstrated by the test data of window guard #4 for instance. The design is especially important when the materials used in the construction of the guard are relatively weak and small, for esthetic reasons. A particularly complex design will force the intruder to spread several bars before gaining access to the premisces, even if the required forces are not overwhelming.

The bar spreading resistance of several of the window guards tested, could easily be improved by incorporating vertical members between the horizontal bars and between the horizontal bars and the framework, as demonstrated by the RCMP models and several of the commercial models.

It is important to point out that the results only reflect the performance of the window guards when subjected to pushing, pulling or spreading forces and do not cover the whole range of possible attacks, such as the use of bolt cutters, and hacksaws. It appears however, that the performance of the guards under the stress tests, might generally give a fair indication of their resistance to cutting or sawing, since the stress test results, reflect primarily the quality of the materials used. These properties should nevertheless be estimated more accurately in a future test. The evaluation should also include

a representative sampling of padlocks, latches, etc., since many guards are not permanently mounted. The resistance of window frames and fasteners to pushing or pulling should also be determined. Nevertheless, only those fasteners that penetrate the concrete or the framing members should be considered when installing guards.

Detailed data from testing 19 different window guards are given in Tables 1 and 2, and summary details of individual guards follow the tables.

CONCLUSIONS

The comparative evaluation of nineteen sets of basement window guards, for their resistance to forcible entry, indicated the following:

- Nine guards failed under loads of 4.4 kN (1000 lbf) or less, during either the straight push test or the bar separation test.
- Six guards failed under loads varying from 4.4 kN to 9.9 kN (1001 lbf to 2000 lbf).
- Three guards were not tested to failure, including two that exceeded the set maximum testing limit of each testing method.
- The RCMP window guards were generally stronger than the commercial guards.
- The home-made guard constructed with water pipes was stronger than nine of the commercial guards tested and two of the RCMP guards.

RECOMMENDATIONS

Testing should be carried out to evaluate the comparative resistance of window guards and various padlocks to cutting or sawing. The study should also include the determination of the resistance of various guard fasteners to pulling, pushing or prying forces.

Table 1. Window Guard Test Results

Sample No.	Straight Push Test (No. 1)	Bar Separation Test (No. 2)	Failure Type	*Load Required to Gain Entry N	(lbf)	Remarks
1A	✓		Window guard & bracket	10,231	(2300)	Top horizontal bar slipped from bracket
1B		✓	Window guard	7,155	(1609)	(1)
2A	✓		Lock bolt Lock bolt	3,559 3,781	(800) (850)	Two loads were required
2B		✓	Window guard	3,150	(708)	(1)
3A	✓		Window guard	7,117	(1600)	(1)
3B		✓	Window guard	19,530	(4390)	(1)
4A	✓		No failure No failure No failure	4,537 6,895 6,895	(1020) (1550) (1550)	Test was discontinued when load application became nearly impossible (deformed guard)
4B		✓	No failure	5,760	(1295)	Test was discontinued when the horizontal bar came in contact with the window frame
5A	✓		Lock bolt	4,226	(950)	
5B		✓	Window guard	3,600	(809)	(1)
6A	✓		Window guard	2,358 3,514	(530) (790)	Two load applications were required
6B		✓	Window guard	4,230	(951)	(1)
7A	✓		Window guard	3,114	(700)	The results might have been higher if installed in a narrower window frame
7B		✓		18,900	(4249)	The results might have been higher if installed in a narrow window frame

Table 1. continued

Sample No.	Straight Push Test (No. 1)	Bar Separation Test (No. 2)	Failure Type	*Load Required to Gain Entry N	(lbf)	Remarks
8A	✓		Locking device	979	(220)	Test was repeated on a permanently fastened guard see (8C)
8B		✓	Window guard	1,530	(344)	(1)
8C	✓		Window guard	2,433	(547)	Guard larger than guards 8A & 8B
9A	✓		Window guard	4,226	(950)	Bar failure
9B		✓		3,330	(749)	Bar Failure
10A	✓		No failure	18,015	(4050)	Test was discontinued after it exceeded the set maximum limit of 17,793 N (4000 lbs)
10B		✓	Window guard	4,230	(951)	(1)
11A	✓		Window guard & fasteners	2,890	(650)	Preliminary test sample, improperly fastened
11B	✓		Window guard	3,150	(708)	Preliminary test sample, properly fastened
11C		✓	Window guard	2,750	(618)	(1)
12A	✓		Guard Failure	3,403 6,672	(765) (1500)	Two load applications were required
12B		✓	Window guard	4,950	(1113)	(1)
13A	✓		Window guard	6,227	(1400)	Weldings failed
13B		✓	Window guard	6,120	(1376)	(1)
14A	✓		Window guard	4,938	(1110)	The two guard sections came apart
14B		✓	Window guard	18,810	(4229)	One horizontal bar was disengaged

Table 1. Continued

Sample No.	Straight Push Test (No. 1)	Bar Separation Test (No. 2)	Failure Type	*Load Required to Gain Entry N	(lbf)	Remarks
15A	✓		Window guard	6,450 3,158	(1450) (710)	Two load applications were required
15B		✓	Window guard	2,340	(526)	(1)
16A	✓		No failure	17,793	(4000)	Test discontinued at the set maximum limit
16B		✓	Window frame (no guard failure)	25,290	(5685)	Test was discontinued
17A	✓		No failure	17,793	(4000)	Test discontinued at the set maximum limit
17B		✓	No failure	26,690	(6000)	Test discontinued at the set maximum limit
18A	✓		Window guard	11,076 4,470	(2490) (1005)	Two load applications were required
18B		✓	Window frame (no guard failure)	20,700	(4654)	Test was discontinued
19A	✓		Window guard	6,681	(1502)	Bar was pulled from the window frame
19B		✓		5,130	(1153)	(1)

* Load required to produce an opening measuring a minimum of 191 mm x 305 mm (7½ in. x 12 in.)

(1) The opening size could have been increased further, with a lesser load, since the ultimate load had already been reached.

Table 2. Classification of Window Guard Failures

Sample No.	Test		Force Required to Gain Entry					
	Push	Spreading	0 - 2.2 kN (1-500 lbf)	2.2 - 4.4 kN (501-1000 lbf)	4.4 - 6.7 kN (1001-1500 lbf)	6.7 - 8.9 kN (1501-2000 lbf)	8.9 - 11.1 kN (2001-2500 lbf)	No Failure Within Maximum Limits
1		✓				✓		
2		✓		✓				
3	✓					✓		
4	-	-						✓ *
5		✓		✓				
6	✓			✓				
7	✓			✓				
8	✓		✓					
9		✓		✓				
10		✓		✓				
11		✓		✓				
12		✓			✓			
13		✓			✓			
14	✓				✓			
15		✓		✓				
16	-	-						✓
17	-	-						✓ **
18	✓						✓	
19		✓			✓			
Total	6	10	1	8	4	2	1	3

* Test discontinued due to the complexity of the design.
** Test No. 2 (spreading test) was discontinued following a window frame failure.

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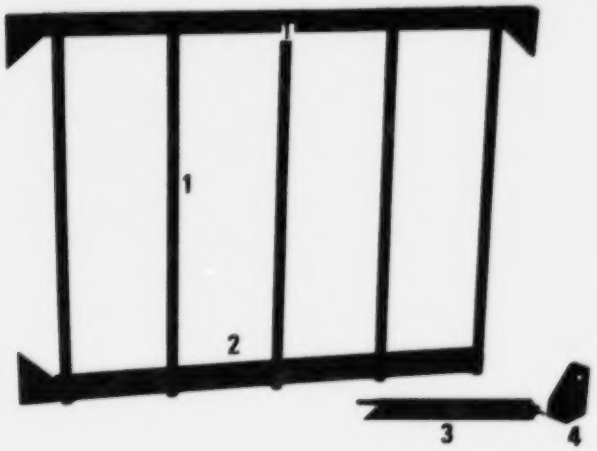
INDIVIDUAL WINDOW GUARD RESULTS

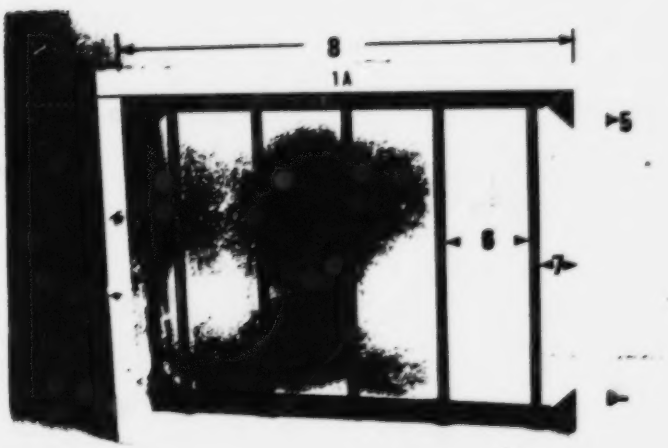


1) Steel rods 12.5 mm diameter ($\frac{1}{2}$-in.)

2) Square tubing 25 mm x 25 mm x 533 mm (1-in. x 1-in. x 21 in.)

3) Adjustable 19 mm square tubing ($\frac{3}{4}$-in.)

4) Interior mounts



5) 6.35 mm ($\frac{1}{4}$-in.) diameter machine bolts

6) 127 mm (5-in.) bar separation

7) 57 mm ($2\frac{1}{4}$-in.) separation between bar and jamb

8) 625 mm (24 5/8 in.)

9) 457 mm (18 in.)

FIGURE 8. Window Guard #1 Before Test

WINDOW GUARD #1

MATERIALS AND DESIGN

Window guard #1 is a fixed guard consisting of five vertical steel rods, welded onto the surface of two pieces of square tubing. The guard is mounted in the center of the window frame; fitting is done with four adjustable fasteners that slide inside the square tubing. Window guard #1 is shown in Figure 8.

FIGURE 9. Window Guard #1 After the Straight Push Test

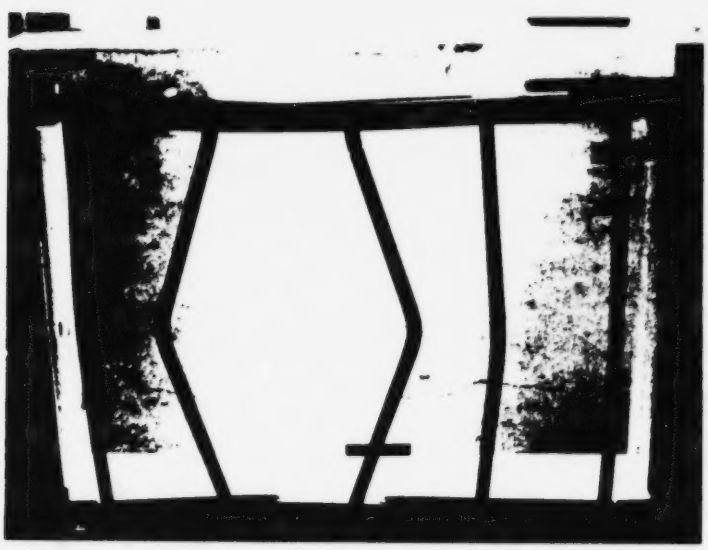


FIGURE 10. Window Guard #1 After the Bar Separation Test

RESULTS

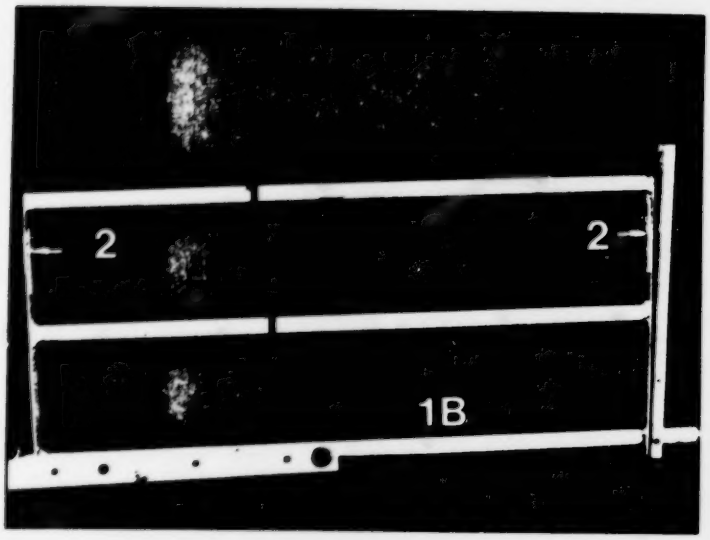
The straight push test was conducted by applying a load near the top of the middle vertical steel rod. The test results indicated that a load of 10,231 N (2300 lbf) was required to bend the top horizontal piece of square tubing to the point where it pulled out from the top brackets.

The guard could then easily be pushed by hand. Figure 9 shows guard #1 following test.

The bar spreading test was conducted between the second and third vertical steel rod, at mid-height. The test results indicated that a load of 7155 N (1609 lbf) was required to produce an opening large enough to allow entry. The separation between bars was increased from 127 mm (5 in.) to 229 mm (9 in.). Figure 10 shows the guard following the spreading test.

CONCLUSION

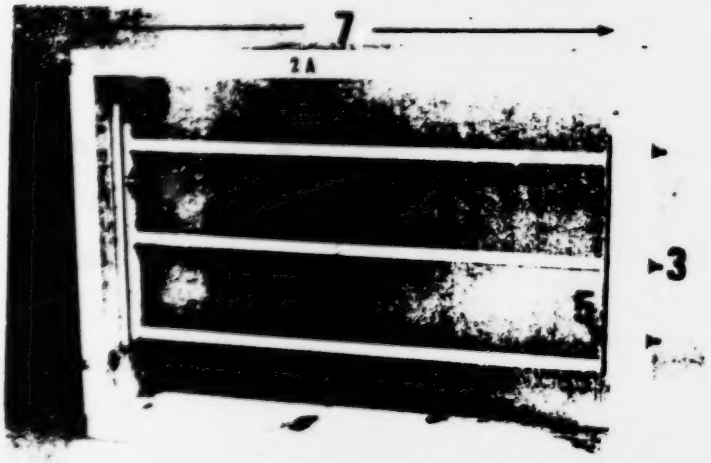
The test data showed that a spreading force of 7155 N (1609 lbf) was required to gain entry through guard #1, while a load of 10,231 N (2300 lbf) was needed using the straight push method.



1) 16 mm (5/8 in.) diameter steel rods

1B) Steel rod fixed to the frame

2) Lock



3) 6.35 mm (¼ in.) diameter machine bolts

4) 114 mm (4½ in.) bar separation

5) 3 mm x 32 mm (1/8 in. x 1¼ in.) flat steel bars

6) 12.5 mm x 32 mm (½ in. x 1¼ in.) U-channels

7) 668 mm (26 5/8 in.)

8) 457 mm (18 in.)

FIGURE 11. Window Guard #2 Before Test

WINDOW GUARD #2

MATERIALS AND DESIGN

Window guard #2 is an interior opening guard, equipped with two locks. It opens by pivoting around the lower steel rod. In the opened position, the guard may serve as an aid to climb out of a basement, in case of emergency. It consists of two horizontal steel rods welded to flat steel bars and a third rod extending through the U-channels mounted on the jambs. The guard is shown in Figure 11.

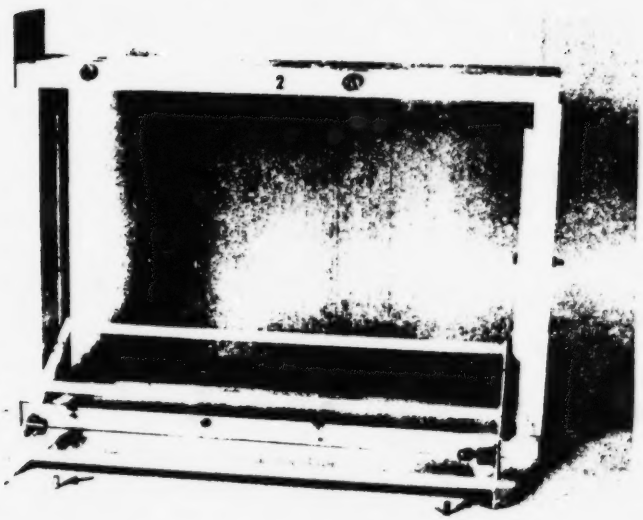


FIGURE 12. Window Guard #2 After the Straight Push Test

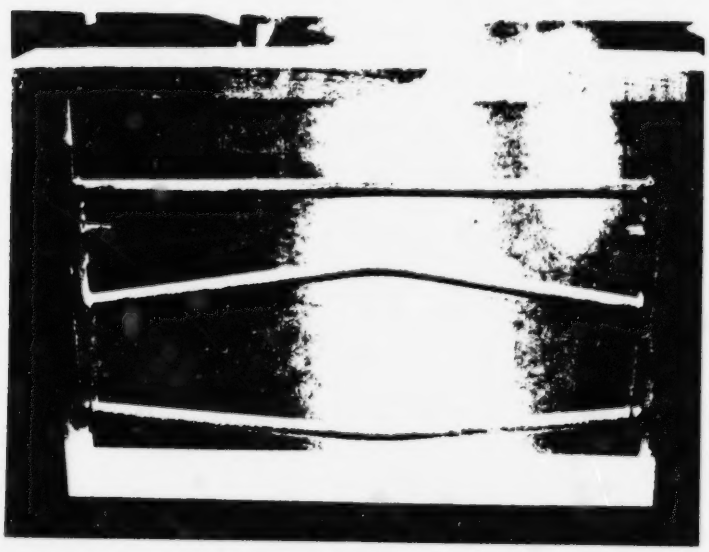


FIGURE 13. Window Guard #2 After the Bar Separation Test

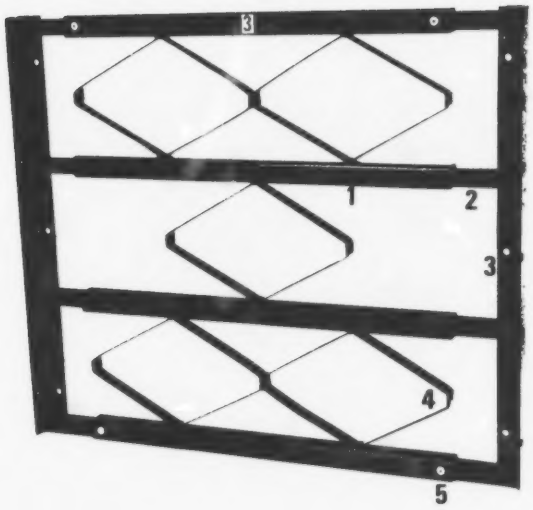
RESULTS

The straight push test was conducted by applying a load near the left lock, followed by a load application near the right lock. The results indicated that the lock bolts failed at 3559 N (800 lbf) and 3781 N (850 lbf), respectively. Figure 12 shows the guard following test.

The spreading test conducted between the lower two horizontal steel rods, indicated that a load of 3150 N (708 lbf) is required to produce an opening large enough to allow entry (Figure 13). The separation between bars was increased from 114 mm (4½ in.) to 191 mm (7½ in.).

CONCLUSION

The test data indicated that the locking devices of guard #2 are more resistant to forcible entry than the guard itself. The locks failed at 3559 N (800 lbf) and 3781 N (850 lbf) respectively, while the bars failed at 3150 N (708 lbf).



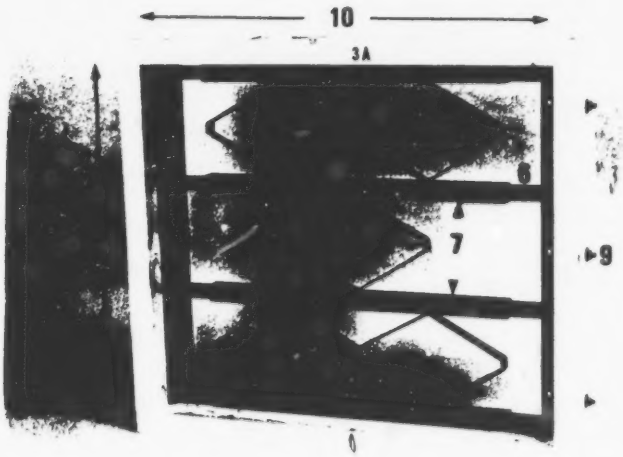
1) Square tubing, 25 mm x 457 mm (1 in. x 18 in).

2) Square tubing that slide into the 25 mm (1 in.) tubing; 19 mm x 254 mm ($\frac{3}{4}$ in. x 10 in.)

3) 3 mm x 32 mm (1/8 in. x $1\frac{1}{4}$ in.) L-shape steel bars

4) 1.6 mm x 19 mm (1/16 in. x $\frac{3}{4}$ in.) flat steel

5) Pop rivets



6) Exposed section of 19 mm ($\frac{3}{4}$ in.) square tubing 11 mm ($4\frac{1}{2}$ in.)

7) 146 mm ($5\frac{3}{4}$ in.) bar separation

8) 222 mm ($8\frac{3}{4}$ in.)

9) 6.35 mm ($\frac{1}{4}$ in.) bolts

10) 613 mm (24 1/8 in.)

11) 524 mm (20 5/8 in.)

FIGURE 14. Window Guard #3 Before Test

WINDOW GUARD #3

MATERIALS AND DESIGN

Window guard #3 is a fixed guard. Each horizontal bar is made up of two sizes of square tubing; the smaller sliding into the larger tubing. These are welded onto the surface of two vertical L-shaped steel bars. Flat steel diamond shaped, decorative pieces, are inserted between the horizontal components of the guard. This guard is shown in Figure 14.

FIGURE 15. Window Guard #3 After the Straight Push Test

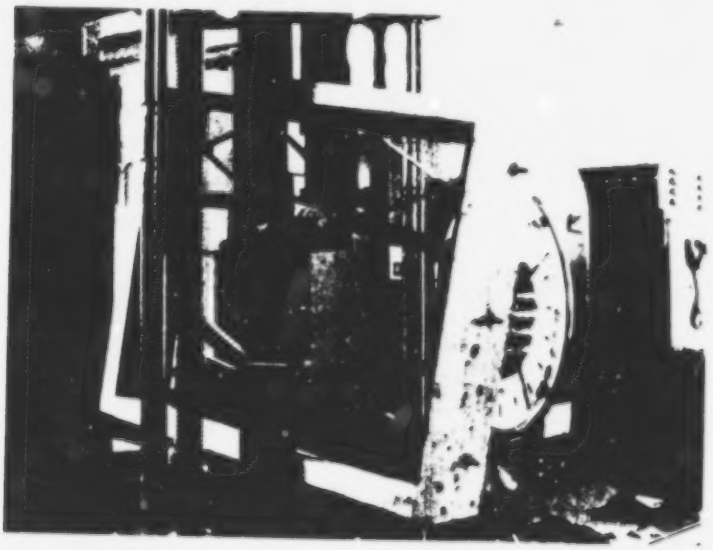


FIGURE 16. Window Guard #3 During the Bar Separation Test

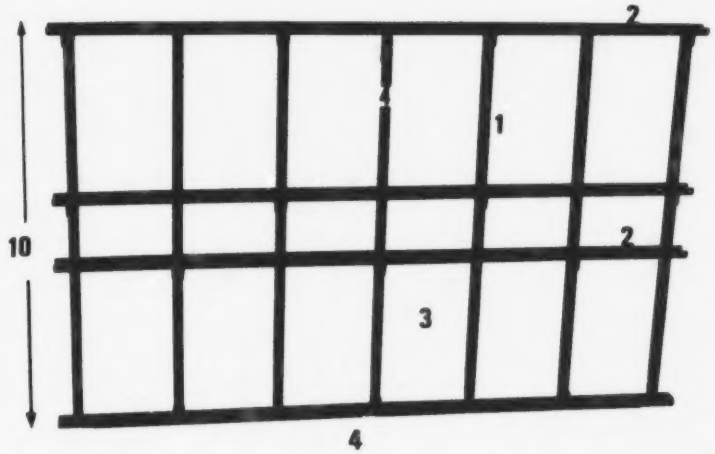
RESULTS

The straight push test was conducted by applying a load to the center of the second horizontal bar from the top. The results indicated that a load of 7111 N (1600 lbf) was required to push the middle of the horizontal bar 260 mm (10¼ in.) from its original position, producing an opening large enough to allow entry. Figure 15, shows the guard following test.

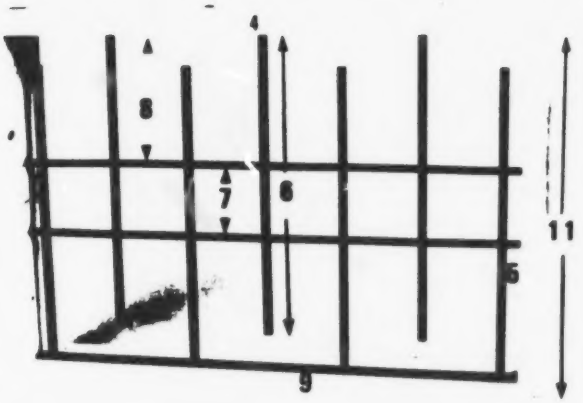
The bar spreading test was conducted at the centre of the guard, between the middle horizontal bars. The test results indicated that a load of 19530 N (4390 lbf) was required to produce an opening large enough to allow entry. The separation between bars was increased from 146 mm (5¾ in.) to 254 mm (10 in.). Figure 16, shows guard #3 during test.

CONCLUSION

The test data showed that a spreading force of 19530 N (4390 lbf) was required to gain entry through guard #3, while a load of 7117 N (1600 lbf) was sufficient using the straight push method.



1) 10 mm (3/8 in.) square bars
2) 19 mm x 2 mm ($\frac{3}{4}$ in. x 3/32 in.) flat steel
3) 102 mm (4 in.) bar separation
4) 640 mm (26 in.)



5) 25 mm (1 in.) bar frame separation
6) bars 406 mm (16 in.) in length
7) 102 mm (4 in.)
8) 178 mm (7 in.)
9) 38 mm ($1\frac{1}{2}$ in.) No. 11 wood screws
10) 413 mm ($16\frac{1}{4}$ in.) (closed position)
11) 457 mm (18 in.)

FIGURE 17. Window Guard #4 Before Test

WINDOW GUARD #4

MATERIALS AND DESIGN

Window guard #4 is an adjustable guard, consisting of seven vertical steel bars, welded alternatively to the top or lower horizontal piece of flat steel. The bars are held firmly together, in the expanded position, by two pieces of flat steel located on each side of the center of the guard. Figure 17 shows the guard in both the closed and expanded position.

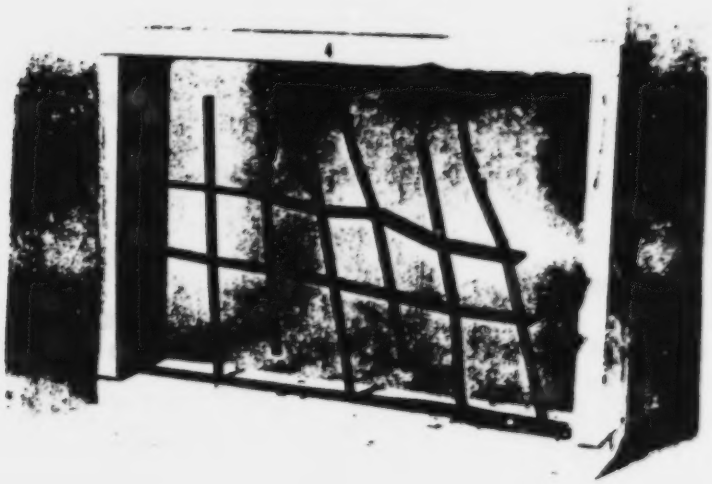


FIGURE 18. Window Guard #4 After the Straight Push Test

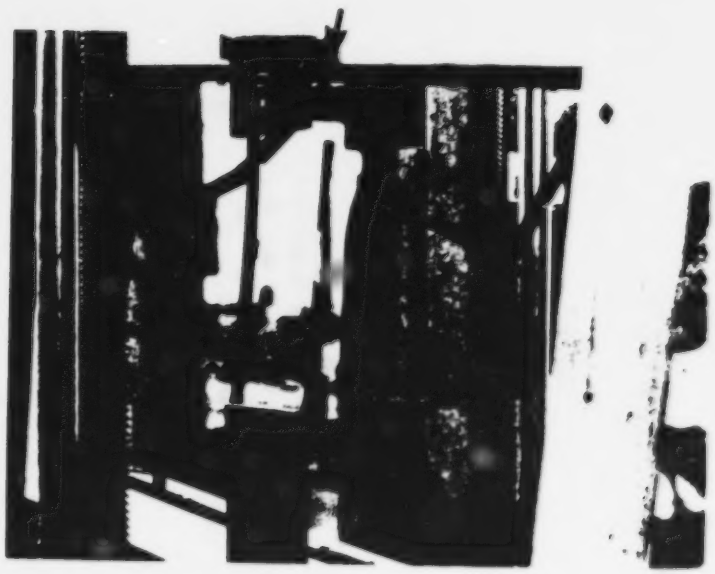


FIGURE 19. Window Guard #4 During the Bar Separation Test

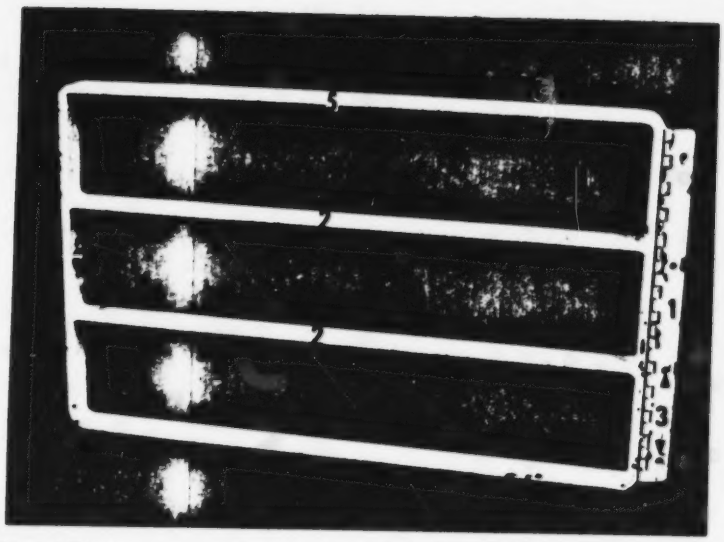
RESULTS

The straight push test results indicated, that even after applying sequential loads to three separate vertical steel bars, entry through guard #4 was still not possible. The first bar sustained a load of 4537 N (1020 lbs), and the two other bars 6895 N (1550 lbs) each, before the tests had to be discontinued (impossible to apply the load, because the bars were twisted). Figure 18 shows the guard following test.

The bar spreading test was conducted between the horizontal bars, at the center of the guard. Testing had to be discontinued at a load of 5760 N (1295 lbs), after the separation between bars had been increased from 102 mm (4 in.) to 330 mm (13 in.), since the top horizontal bar was resting against the window frame (Figure 19, arrow).

CONCLUSION

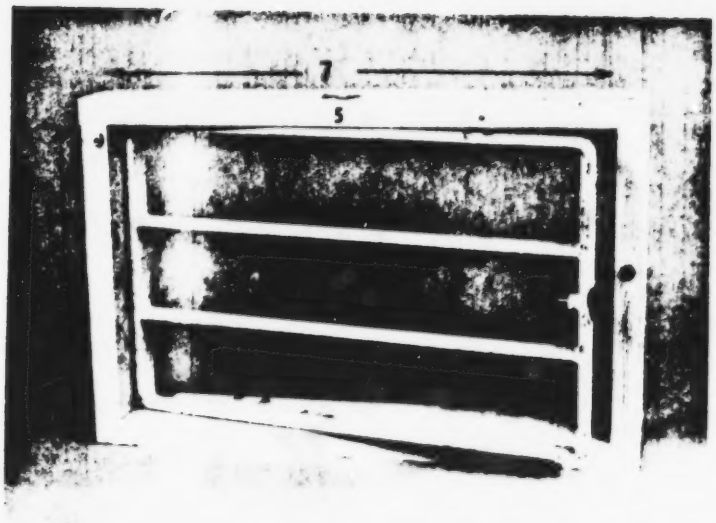
Testing showed that it was impossible to break-in through window guard #4 using reasonable efforts, by either the straight push method or the spreading method. The guard components were twisted at relatively small loads [6895 N or less (1500 lbs)] but the complex design of the guard restricted the opening size, even after several load applications.



1) Piano hinge

2) 32 mm x 10 mm (1¼ in. x 3/8 in.) flat steel

3) Slots in piano hinge; four 38 mm (1½ in.) No. 12 wood screws were used to fasten hinge.



4) Keyed lock

5) 6.35 mm x 38 mm (¼ in. x 1½ in.) latch plate was added

6) 114 mm (4½ in.) separation

7) 813 mm (32 in.)

8) 457 mm (18 in.)

FIGURE 20. Window Guard #5 Before Test

WINDOW GUARD #5

MATERIALS AND DESIGN

Window guard #5 is hinged (piano hinge) and opens towards the interior. The outer frame is made up of flat steel, bent to form the corners. The two horizontal steel bars are of the same material; they are welded to the sides of the metal frame. The assembly is kept closed by a key operated lock. This window guard is shown in Figure 20.

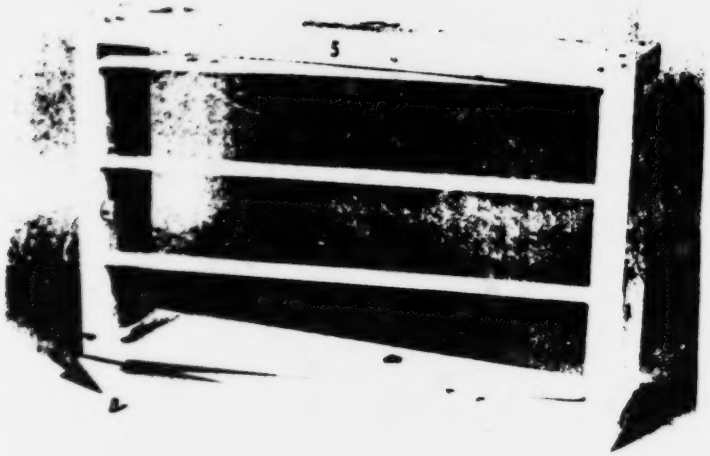


FIGURE 21. Window Guard #5 After the Straight Push Test

FIGURE 22. Window Guard #5 During the Bar Separation Test

RESULTS

The straight push test was conducted near the lock area. The load was increased up to 4226 N (950 lbs), at which point, the lock bolt broke (Figure 21, arrow) and the guard could be opened.

The bar spreading test was conducted at the center of the guard, between the two horizontal bars. The test results indicated that a load of 3600 N (809 lbs) was required to produce an opening large enough to allow entry. The separation between bars was increased from 114 mm (4½ in.) to 191 mm (7½ in.). Figures 22 and 23 show guard #5 during test and after test respectively.

CONCLUSION

The test data indicated that the locking device of guard #5 is more resistant to forcible entry than the guard itself. The lock failed at 4226 N (950 lbs), while the bars failed at 3600 N (809 lbs).

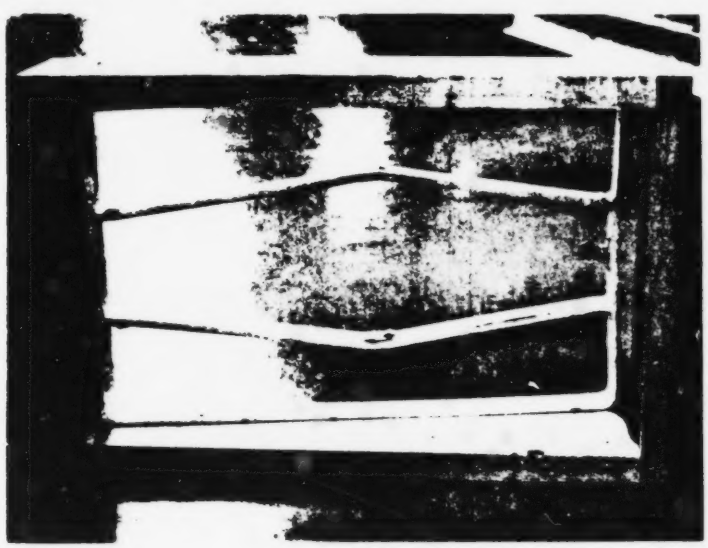


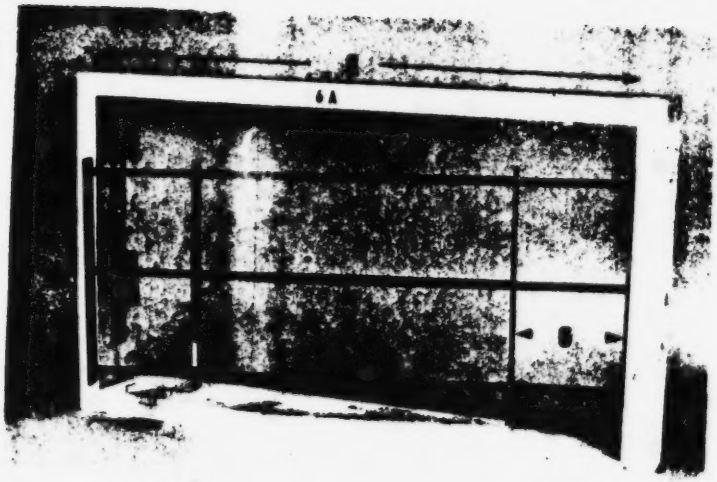
FIGURE 23. Window Guard #5 After the Bar Separation Test

1) 10 mm (3/8 in.) diameter, parallel steel rods

2) 32 mm x 5 mm (1¼ in. x 3/16 in.) slotted flat steel bars

3) Piano hinge, slotted to receive 38 mm (1½ in.) No. 12 wood screws

4) Padlock, locked onto steel plate



5) Steel plate to receive padlock

6) 203 mm (8 in.)

7) 133 mm (5¼ in.)

*8) 813 mm (32 in.)

9) 457 mm (18 in.)

*660 mm (26 in.) in the closed position

FIGURE 24. Window Guard #6 Before Test

WINDOW GUARD #6

MATERIALS AND DESIGN

Window guard #6 is an adjustable guard; it is hinged (piano hinge) and opens towards the interior. The guard is kept closed by a padlock. The guard has six horizontal steel rods; three on each side of the guard. These rods are welded to vertical flat steel plates. The rods of one part of the guard, slide through the slotted, vertical flat steel plate of the second part of the guard, allowing the system to adapt to various frame widths. The guard is shown in Figure 24.

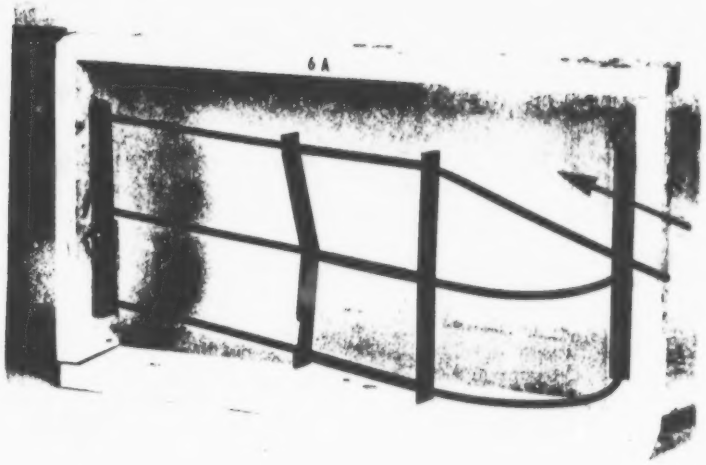


FIGURE 25. Window Guard # 6 After the Straight Push Test

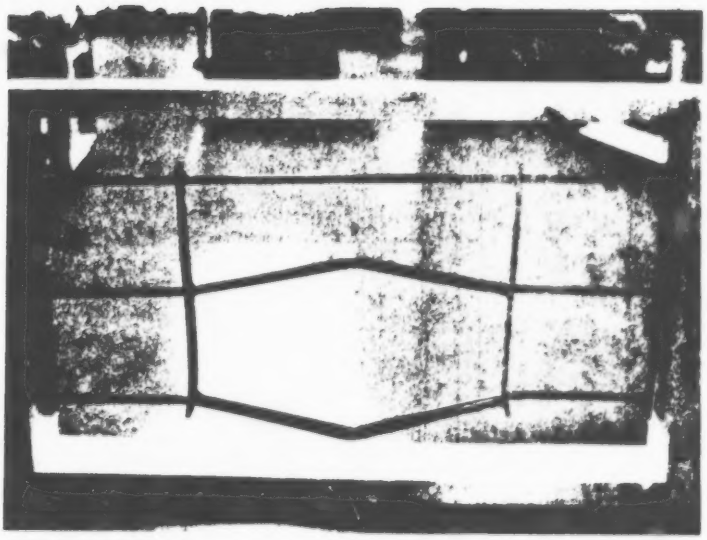


FIGURE 26. Window Guard #6 After the Bar Separation Test

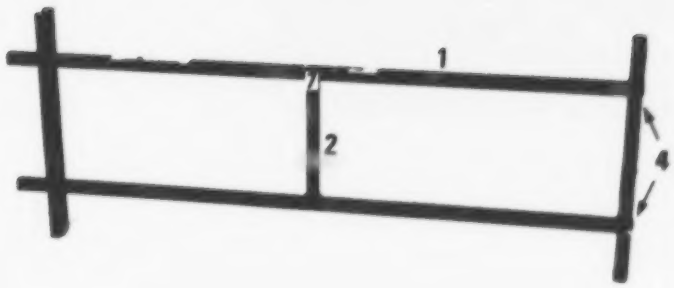
RESULTS

The straight push test was conducted by first, applying a load to the top horizontal rod, followed by a load application to the middle rod. The joint between the top rod and the vertical flat steel plate broke at a load of 2358 N (530 lbs). It was then possible to push the bar by hand. The second load was then applied until the window guard was pushed to the point where entry could be gained (254 mm or 10 in. from its original position) through the opening produced at the right top side of the guard (Figure 25 arrow). A load of 3514 N (790 lbs) was required.

The bar spreading test conducted between the lower two horizontal rods (at the center of the guard) indicated that a load of 4230 N (951 lbs) was required to produce an opening large enough to allow entry. The separation between bars, was increased from 133 mm (5¼ in.) to 222 mm (8¾ in.). Figure 26, shows window guard #6 following the spreading test.

CONCLUSION

The test data indicated that a spreading force of 4230 N (951 lbs) was required to allow entry through guard #6. The data also showed that a load of 2358 N (530 lbs) on the top horizontal rod, followed by a load of 3514 N (790 lbs) on the middle horizontal rod was sufficient to cause failure of the guard.

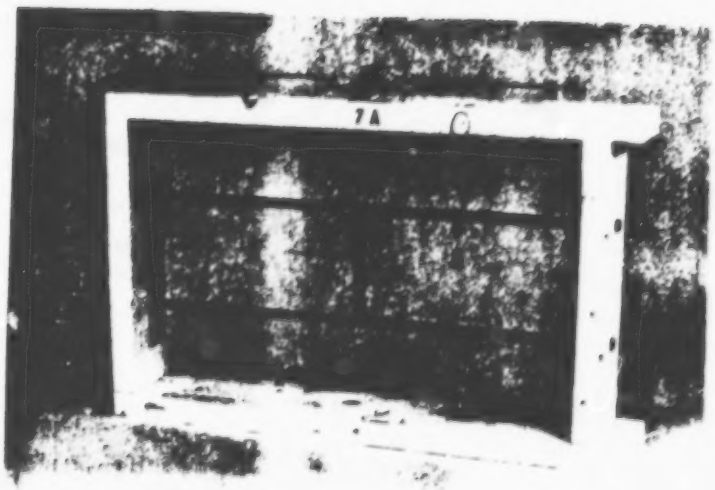


1) 12.5 mm ($\frac{1}{2}$ in.) square steel bars

2) Vertical bar welded between horizontal bars

3) 25 mm x 12.5 mm (1 in. x $\frac{1}{2}$ in.) U-channel

4) Set screws to secure guard in place



5) 108 mm (4$\frac{1}{4}$ in.)

6) 140 mm (5$\frac{1}{2}$ in.)

7) 286 mm (11$\frac{1}{4}$ in.)

8) 648 mm (25$\frac{1}{2}$ in.)

9) 381 mm (15 in.)

FIGURE 27. Window Guard #7 Before Test

WINDOW GUARD #7

MATERIALS AND DESIGN

Window guard #7 is a fixed guard, consisting of two horizontal square steel bars, a vertical bar welded to the horizontal bars in the center and two U-channels mounted onto the frame. The horizontal bars pass through holes in the channels and the jambs. Two set screws mounted on one of the U-channels secure the guard in place. Window guard #7 is shown in Figure 27.

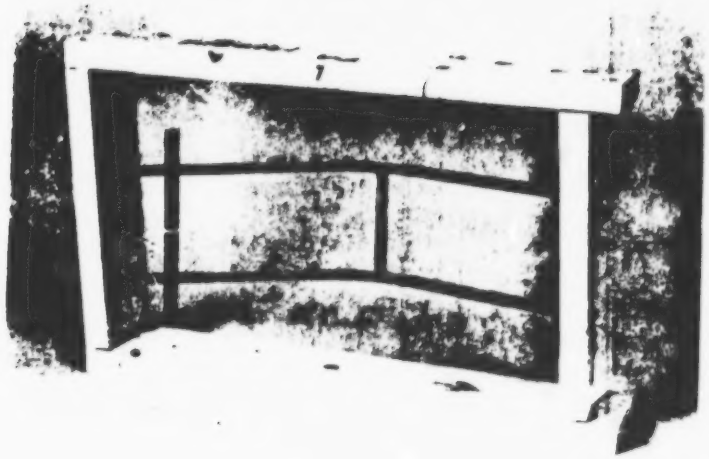


FIGURE 28. Window Guard #7 After the Straight Push Test

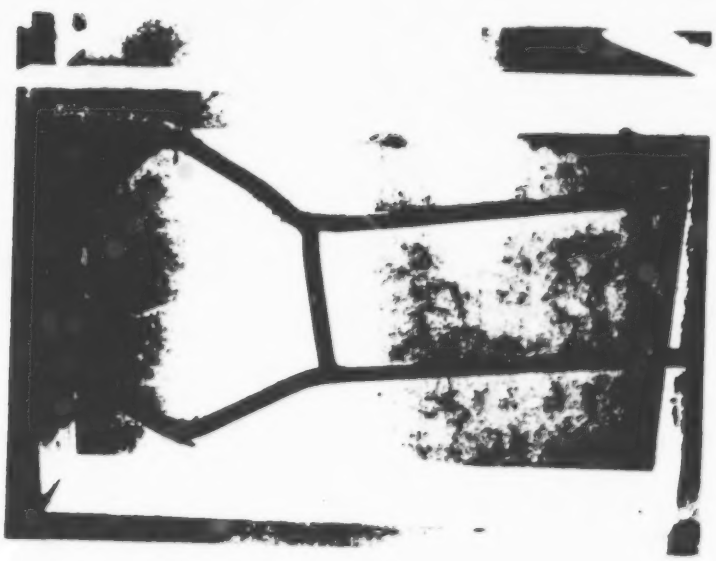


FIGURE 29. Window Guard #7 After the Bar Separation Test

RESULTS

The straight push test was conducted by applying a load to the center of the guard. The horizontal bars where pulled from the left jamb (Figure 28), at a load of 3114 N (700 lbs), after the center of the guard had been pushed in, 155 mm (6.1 in.) from its original position.

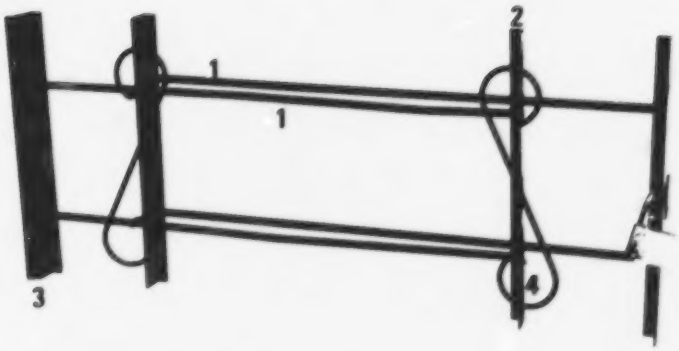
The bar spreading test was conducted between the horizontal bars on the left side of the guard. The horizontal bars were progressively pulled from the holes in the right side of the window frame, as the distance between the bars increased.

This pulling effect finally caused the horizontal bars to disengage from the window frame (Figure 29) at a load of 18900 N (4249 lbs) after the separation between bars had been increased from 140 mm (5½ in.) to 279 mm (11 in.); the guard could then be removed.

CONCLUSION

The test data indicated that a spreading force of 18900 N (4249 lbs) is required to gain entry through guard #7. On the other hand the data showed that a load of 3114 N (700 lbs) was sufficient to cause failure of the guard when the straight push method is used.

The window guards might have performed better had they been installed in narrower window frames.

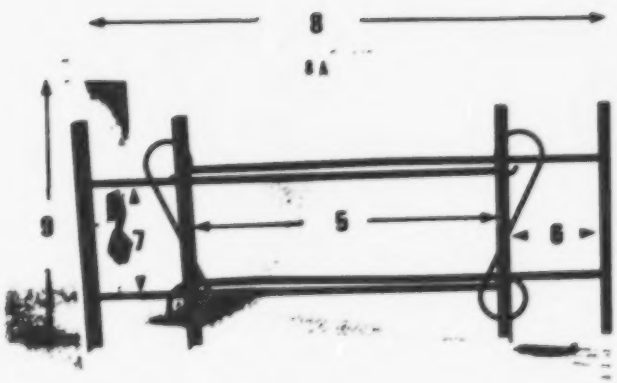


1) 10 mm (3/8 in.) diameter steel rods

2) 25 mm x 12.5 mm x 1.6 mm (1 in. x ½ in. x 1/16 in.) slotted steel angles

3) Piano hinge

4) Decorative designs



5) 432 mm (17 in.)

6) 140 mm (5½ in.)

7) 127 mm (5 in.)

*8) 711 mm (28 in.)

9) 381 mm (15 in.)

* 584 mm (23 in.) in the closed position

FIGURE 30. Window Guard #8 Before Test

WINDOW GUARD #8

MATERIALS AND DESIGN

Window guard #8 is an adjustable guard; it is hinged (piano hinge) and usually opens towards the interior. The guard is kept closed by a padlock and a hasp mounted on the window frame. The guard consists of four steel rods welded to steel angles. The rods (2) of one part of the guard slide through the vertical slotted steel angle of the second part, allowing the system to adapt to various frame widths. The system incorporates two purely decorative patterns, made of steel rods. This guard is shown in Figure 30.

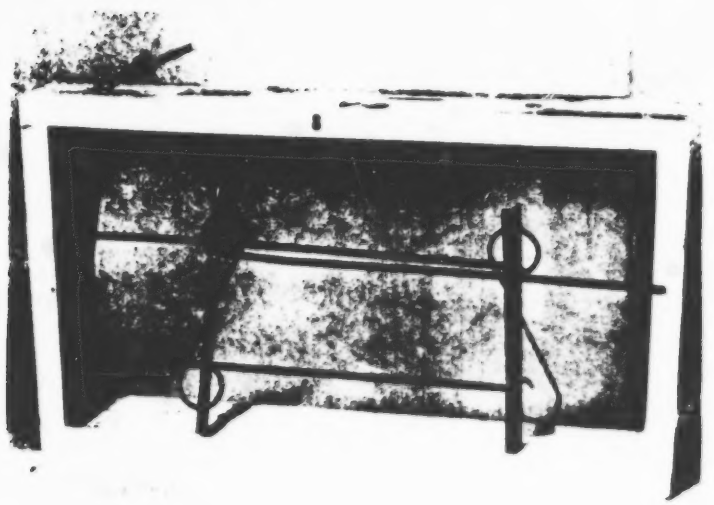


FIGURE 31. Window Guard #8 After the Straight Push Test

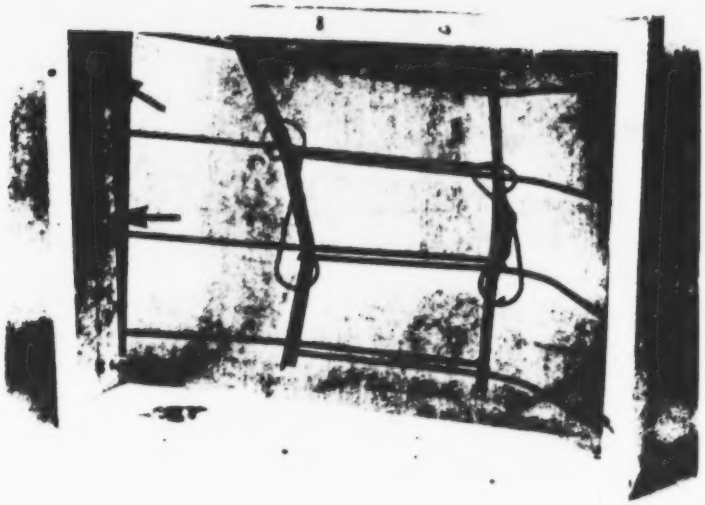


FIGURE 32. Permenently Mounted Guard After the Straight Push Test

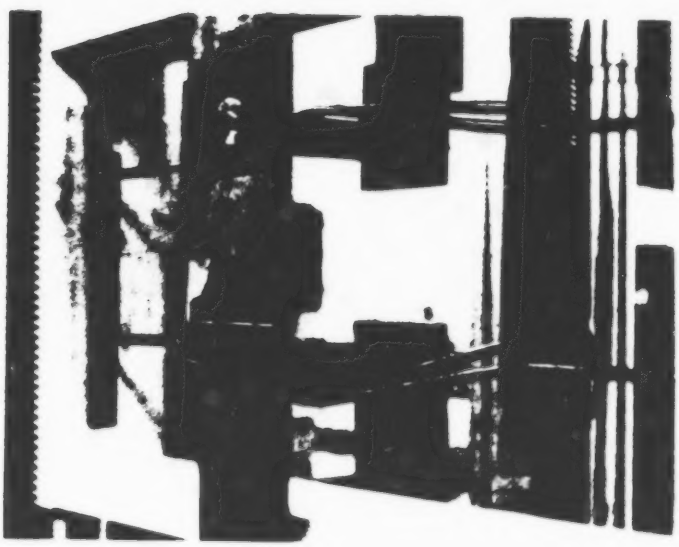


FIGURE 33. Window Guard #8 During Bar Separation Test

RESULTS

The straight push test was conducted by applying a load to the center of the vertical steel angle, adjacent to the lock. Since the hasp staple (Figure 31 arrow) broke off early in the test (979 N or 220 lbs) a second window guard was tested.

The replacement window guard had eight horizontal bars instead of four (Figure 32). The guard was permanently mounted, by attaching the slotted end with screws. The guard failed at a load of 2433 N (547 lbs), after it had deflected 221 mm (8.7 in.) from its original position. The load caused the piano hinge to tear around the screws (Figure 32, arrows).

The bar spreading test was conducted at the center of the window guard (smaller guard). The test results indicated that a load of 1530 N (344 lbs) was sufficient to produce an opening large enough to allow entry. The separation between bars was increased from 127 mm (5 in.) to 267 mm (10½ in.). Figure 33 shows guard #8 during test.

CONCLUSION

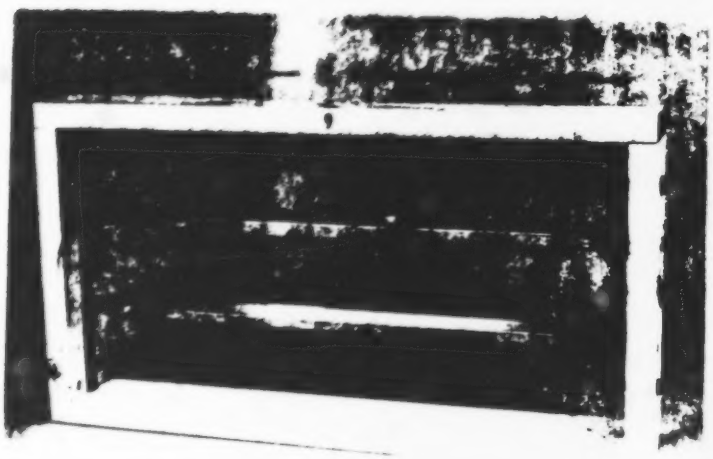
The test data indicated that the hasp staple is the weakest element of the guard (979 N or 220 lbs), when locked with a padlock.

The data also showed that even if the guard is permanently mounted, a spreading force of 1530 N (344 lbs) is sufficient to produce an opening between bars, large enough to allow entry.

WINDOW GUARD #9

MATERIALS AND DESIGN

Window guard #9 is adjustable from 610 mm to 1220 mm (24 in. to 48 in.). It consists of two square tubing sliding one into the other. Each bar is locked in place with a locking pin. The bars have small metal rods at the ends, that slide into slotted vertical flat steel plates located on the window frame. These plates are secured to the frame with 6.35 mm diameter (¼ in.) bolts. This window guard is shown in Figure 34.



1) 19 mm (¾ in.) square tubing
2) 25 mm (1 in.) square tubing
3) Slot for locking pin
4) 127 mm (5 in.)
5) Metal rods, 10 mm diameter x 16 mm in length (3/8 in. x 5/8 in.)
6) 762 mm (30 in.)
6B) 610 mm (24 in.) when in closed position
7) 381 mm (15 in.)
8) 6.35 mm diameter bolts (¼ in.)

FIGURE 34. Window Guard #9 Before Test

RESULTS

The straight push test was conducted by applying a load at the junction of the square tubings of the upper horizontal bar. The bar slipped from the slotted vertical flat steel plates at a load of 4226 N (950 lbs), after deflecting 70 mm, ($2\frac{3}{4}$ in.) from its original position. Entry could then be gained. The damaged bar is shown in Figure 35.

The bar spreading test produced a similar failure (Figure 35). A load of 3330 N (749 lbs) was sufficient to bend one of the bars (at the junction of the square tubings) to the point where it fell off.

CONCLUSION

The test data indicated that the bars of window guard #9 can be removed using a force of 3332 N (749 lbs) or 4226 N (950 lbs) depending on whether the spreading method or the straight push method is used.

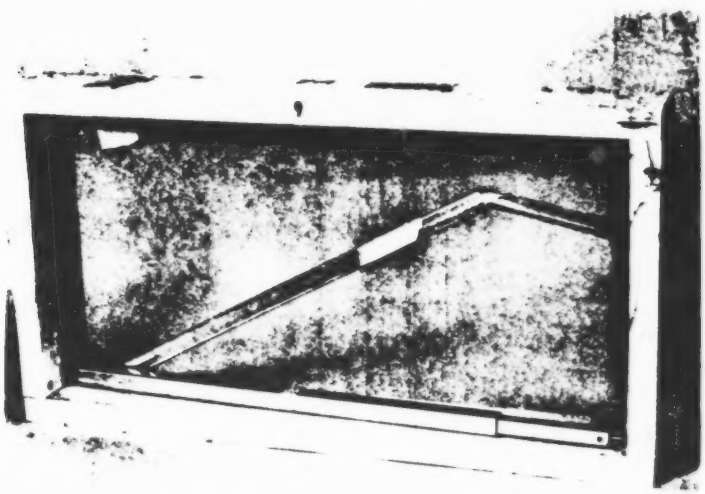
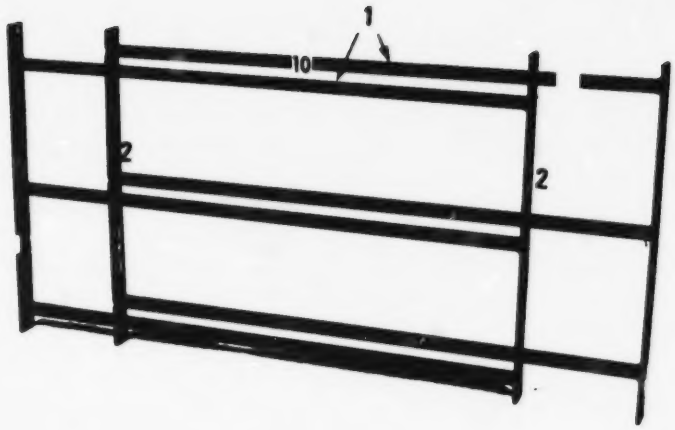
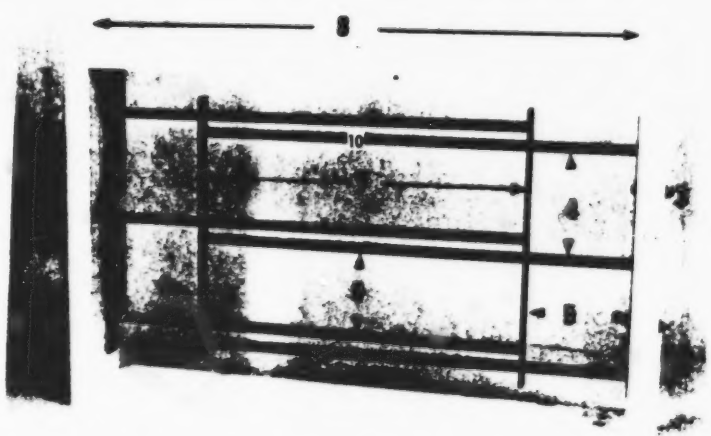


FIGURE 35. Window Guard #9 After the Straight Push Test



1) 12.5 mm ($\frac{1}{2}$ in.) square steel tubing

2) Slotted flat steel plates, 25 mm x 5 mm (1 in. x 3/16 in.)



3) 6.35 mm ($\frac{1}{4}$ in.) diameter bolts

4) 140 mm ($5\frac{1}{2}$ in.)

5) 146 mm ($5\frac{3}{4}$ in.)

6) 114 mm ($4\frac{1}{2}$ in.)

7) 470 mm ($18\frac{1}{2}$ in.)

8) 762 mm (30 in.)

* 629 mm ($24\frac{3}{4}$ in.)

9) 457 mm (18 in.)

* in the closed position

FIGURE 36. Window Guard #10 Before Test

WINDOW GUARD #10

MATERIALS AND DESIGN

Window guard #10 is an adjustable guard consisting of two identical sections, that slide one into the other, to fit window frames of various widths, up to 1118 mm (44 in.). Each section has three horizontal 12.5 mm ($\frac{1}{2}$ in.) square steel tubing, welded onto vertical flat steel plates. This guard is shown in figure 36.

RESULTS

The straight push test was conducted by applying a load to the center of the window guard. The test data showed that guard #10 exceeds the maximum prescribed load (17,793 N or 4000 lbs), when tested in that direction. The test was discontinued at a load of 18,015 N (4050 lbs), after the center of the guard had been pushed in, 254 mm (10 in.) from its original position, while still restricting access. Figure 37, shows guard #10 following test.

The bar spreading test was conducted between the lower horizontal bars (double bars). The test results indicated that a load of 4230 N (951 lbs) was required to produce an opening large enough to allow entry. The separation between bars was increased from 114 mm ($4\frac{1}{2}$ in.) to 222 mm ($8\frac{3}{4}$ in.).

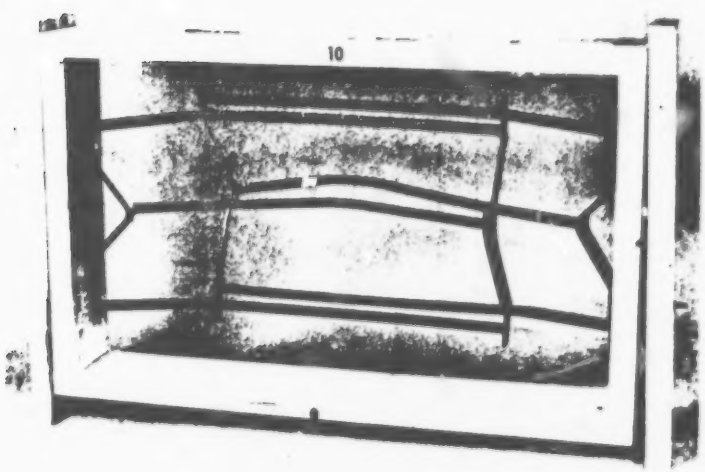


FIGURE 37. Window Guard #10 After the Straight Push Test

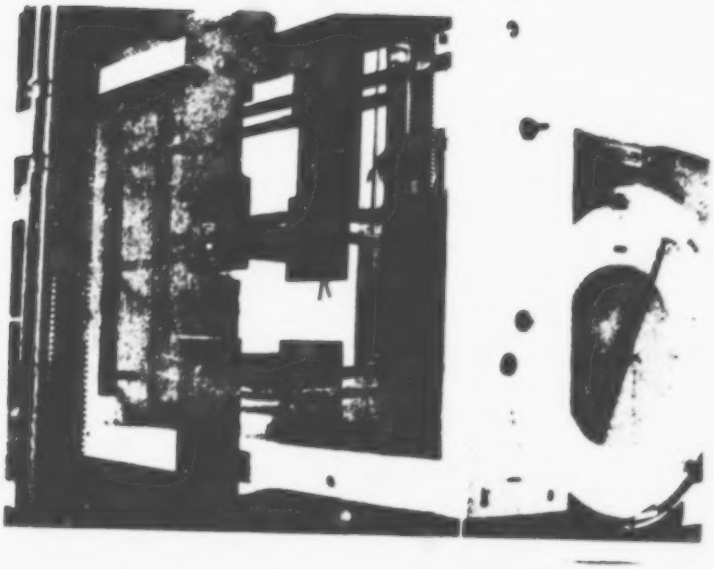


FIGURE 38. Window Guard #10 During the Bar Separation Test

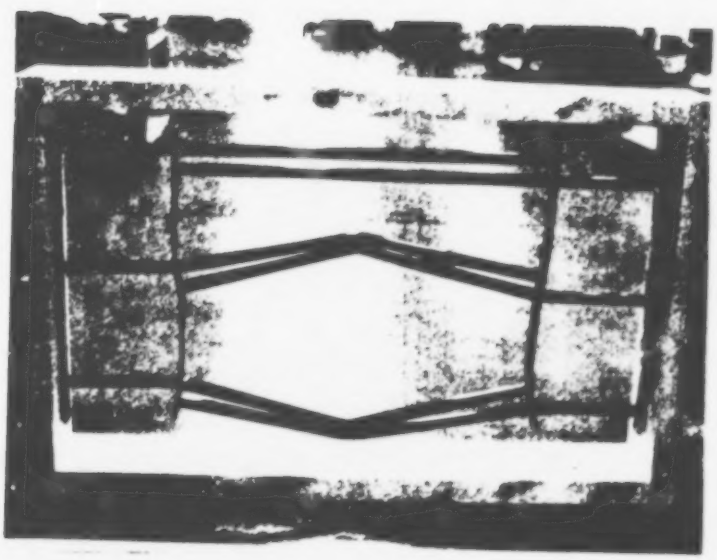
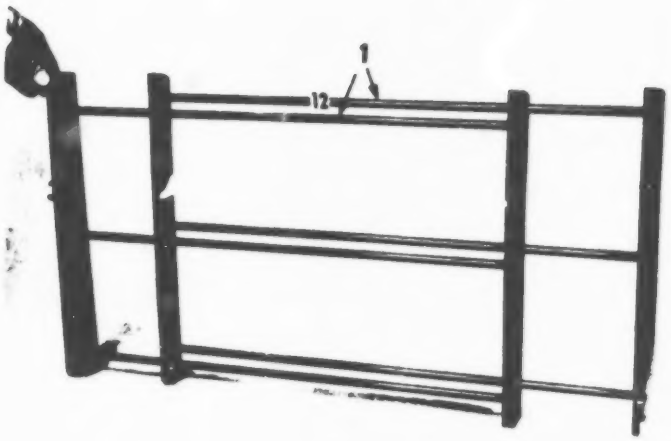


FIGURE 39. Window Guard #10 After the Bar Separation Test

Figure 38 and 39 show Window Guard #10 during and after test

CONCLUSION

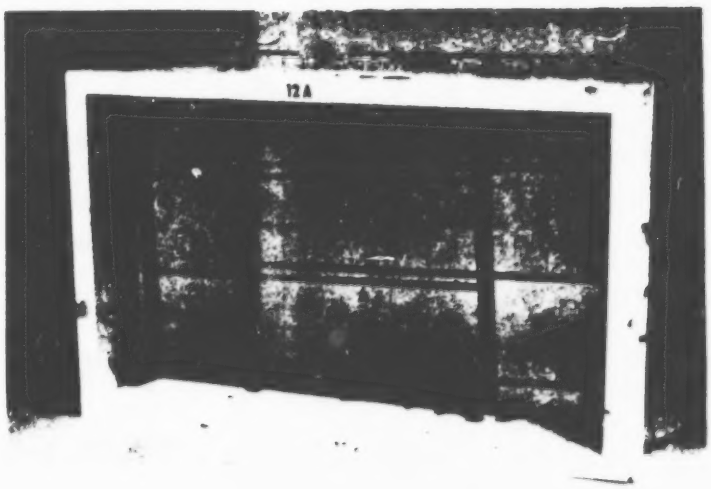
The test data showed that Guard #10 exceeds the set maximum load (17,793 N or 4000 lbs) for the straight push test. However the data also shows that a spreading force of only 4230 N (951 lbs) is sufficient to allow entry between the horizontal bars.



1) 9.5 mm (3/8 in.) diameter steel rods

2) U-channels 22 mm x 19 mm x 1.6 mm (7/8 in. x $\frac{3}{4}$ in. x 1/16 in.)

3) Locking U-channel, designed to receive small U-channel and steel rods, 25 mm x 25 mm x 1.6 mm (1 in. x 1 in. x 1/16 in.)



4) 6.35 mm ($\frac{1}{4}$ in.) diameter bolts

5) 305 mm (12 in.)

6) 203 mm (8 in.)

7) 127 mm (5 in.)

8) 610 mm (24 in.)

9) 457 mm (18 in.)

FIGURE 40. Window Guard #12 Before Test

WINDOW GUARD #12

MATERIALS AND DESIGN

Window Guard #12 is an adjustable guard consisting of two identical sections, that slide one into the other, to fit window frames of various widths; from 610 mm (24 in.) to 1220 mm (48 in.). Each section has three horizontal 9.5 mm (3/8 in.) diameter steel rods, having the ends bent into vertical U-channels. The guard usually opens towards the interior and is kept locked by a padlock that joins the two U-channels opposite to hinged side. Guard #12 is shown in Figure 40.

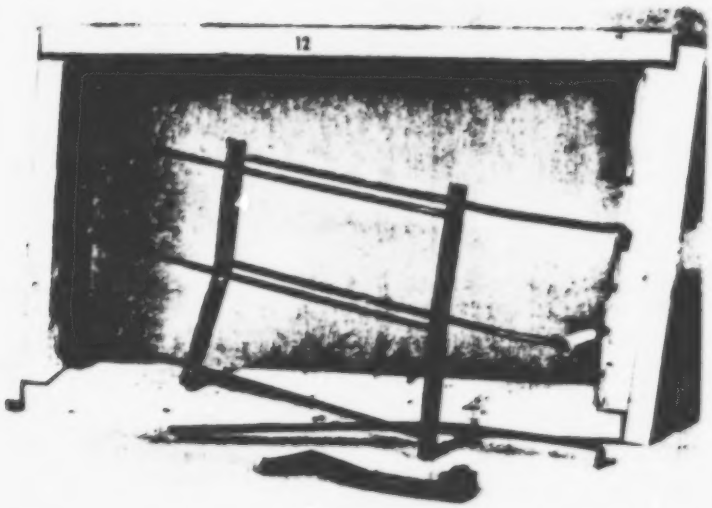


FIGURE 41. Window Guard #12 After the Straight Push Test

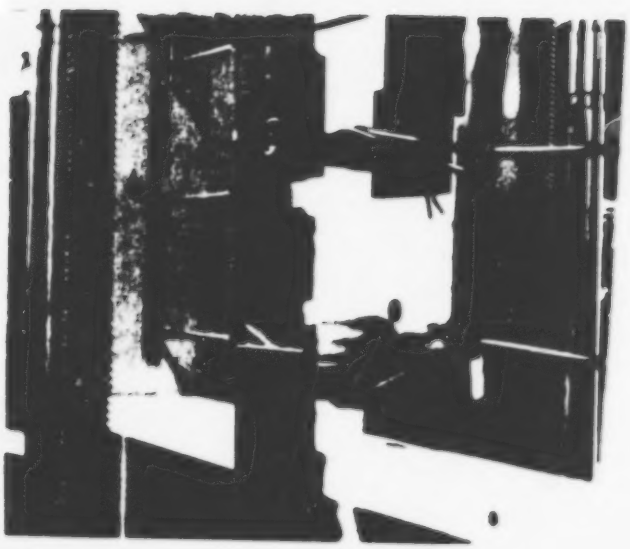


FIGURE 42. Window Guard #12 During the Bar Separation Test

RESULTS

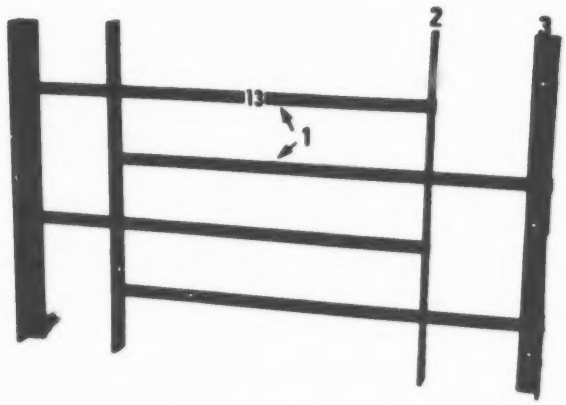
The straight push test was conducted by first applying a load to the middle horizontal bar, near the hinged side; followed by a load application to the same area of the bottom horizontal bar.

Each load caused the perforated U-channel to tear at the bolts, allowing the guard to swing open; the loads were respectively 3403 N (765 lbs) and 6672 N (1500 lbs). The damaged guard is shown in Figure 41.

The bar spreading test conducted between the lower horizontal bars (double bars) indicated that a load of 4950 N (1113 lbs) was required to produce an opening large enough to allow entry. The separation between bars was increased from 127 mm (5 in.) to 229 mm (9 in.). Figure 42, shows guard #12 during test.

CONCLUSION

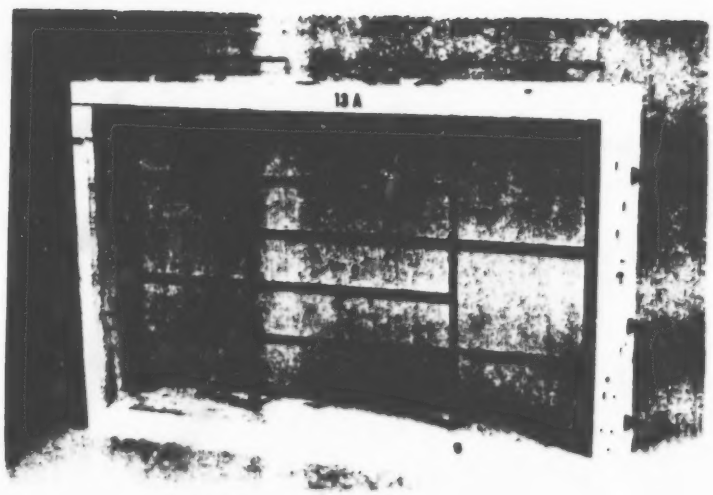
The test data showed that a spreading force of 4950 N (1113 lbs) was required to gain entry through guard #12, while two separate loads of 3403 N (765 lbs) and 6672 N (1500 lbs) were required, when the straight push methods was used.



1) 12.5 mm ($\frac{1}{2}$ in.) steel rods

2) 25 mm x 2.4 mm (1 in. x 3/32 in.) flat steel

3) 25 mm x 3.2 mm (1 in. x 1/8 in.) angle iron



4) 6.35 mm ($\frac{1}{4}$ in.) diameter bolts

5) 203 mm (8 in.)

6) 305 mm (12 in.)

7) 70 mm ($2\frac{3}{4}$ in.)

8) 140 mm ($5\frac{1}{2}$ in.)

9) 184 mm ($7\frac{1}{4}$ in.)

10) 711 mm (28 in.)

11) 445 mm ($17\frac{1}{2}$ in.)

FIGURE 43. Window Guard #13 Before Test

WINDOW GUARD #13

MATERIALS AND DESIGN

Window Guard #13 is an adjustable guard, consisting of two identical sections, that slide one into the other, to fit window frames of various widths; from 533 mm (21 in.) to 965 mm (38 in.). Each section has two horizontal 12.5 mm diameter (½ in.) steel rods welded to 25 mm (1 in.) flat steel at one end, and to 25 mm (1 in.) angle iron, at the other end (against the jamb). Guard #13 is shown in Figure 43.

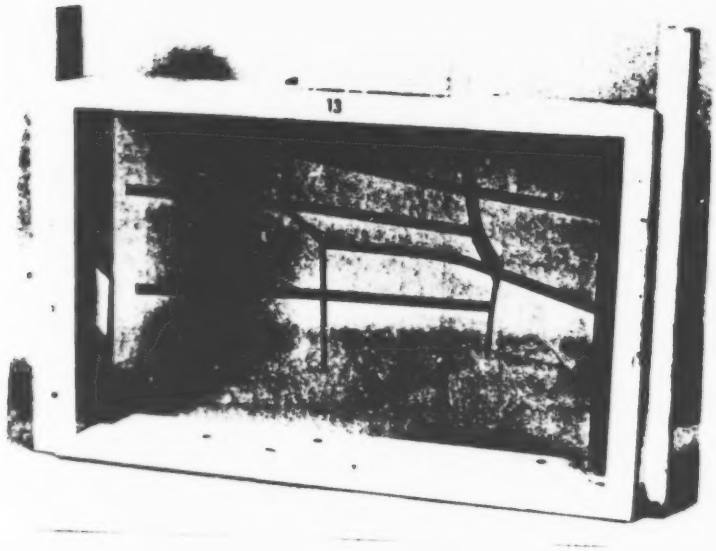


FIGURE 44. Window Guard #13 After the Straight Push Test

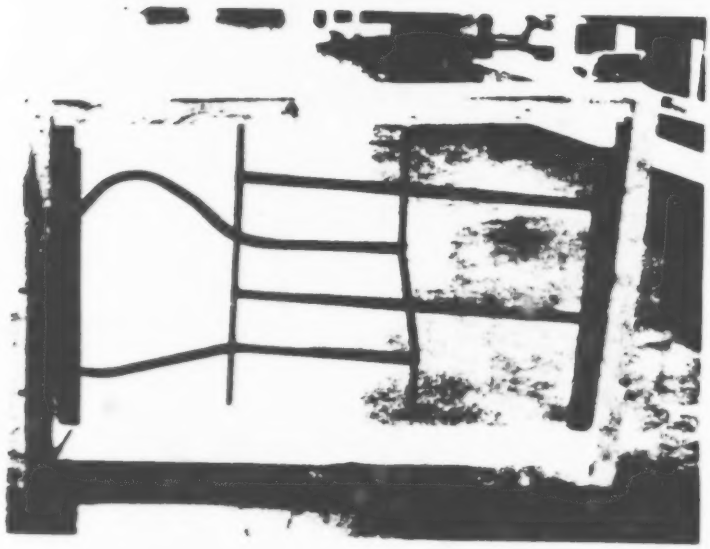


FIGURE 45. Window Guard #13 After the Bar Separation Test

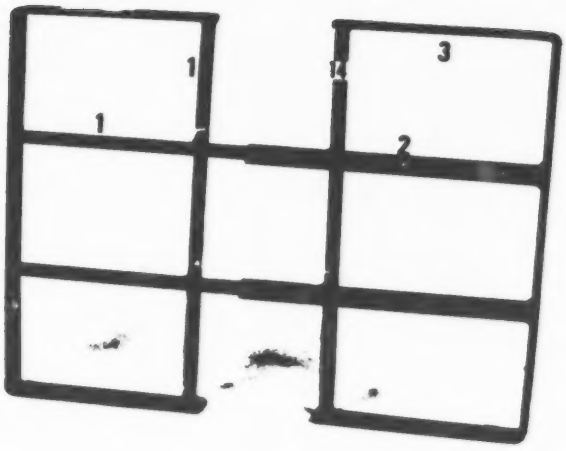
RESULTS

The straight push test was conducted by applying a load to the center of the guard. The results indicated that the weldings joining the horizontal rods to the angle iron and the flat steel, broke at loads of 6227 N (1400 lbs) or less. The bottom part of the guard could then be pushed by hand, allowing entry. The guard is shown in Figure 44.

The bar separation test was conducted between two horizontal rods located at the side of the window guard. The test data indicated that a spreading force of 6120 N (1376 lbs) was required to produce an opening large enough to allow entry. The separation between bars was increased from 140 mm (5½ in.) to 279 mm (11 in.). Figure 45 shows window guard #13 after test.

CONCLUSION

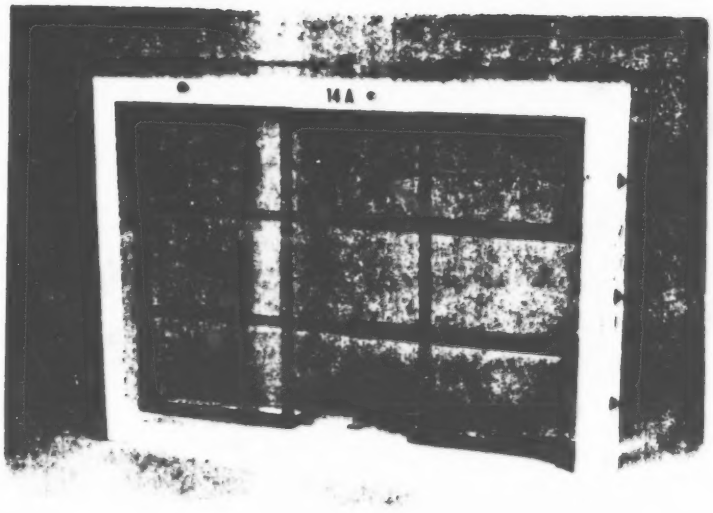
The test data indicated that a load of 6227 N (1400 lbs) is required to gain entry through guard #13 by the straight push test method, and 6120 N (1376 lbs) by the bar separation method.



1) 12.5 mm ($\frac{1}{2}$ in.) square rods

2) 19 mm ($\frac{3}{4}$ in.) square tubing

3) Sections of bent flat steel; 32 mm x 6.25 mm ($1\frac{1}{4}$ in. x $\frac{1}{4}$ in.)



4) 6.35 mm ($\frac{1}{4}$ in.) diameter bolts

5) 216 mm ($8\frac{1}{2}$ in.)

6) 191 mm ($7\frac{1}{2}$ in.)

7) 133 mm ($5\frac{1}{4}$ in.)

8) 660 mm (26 in.)

9) 464 mm ($18\frac{1}{4}$ in.)

FIGURE 46. Window Guard #14 Before Test

WINDOW GUARD #14

MATERIALS AND DESIGN

Window guard #14 is an adjustable guard consisting of two similar sections that slide one into the other. The left section (Figure 46) has two 12.5 mm (1½ in.) horizontal, square steel rods, that slide into the 19 mm (¾ in.) square tubing of the right section. The horizontal components are welded to both vertical square steel rods and to a continuous section (bent at the corners) of 32 mm (1¼ in.) flat steel.

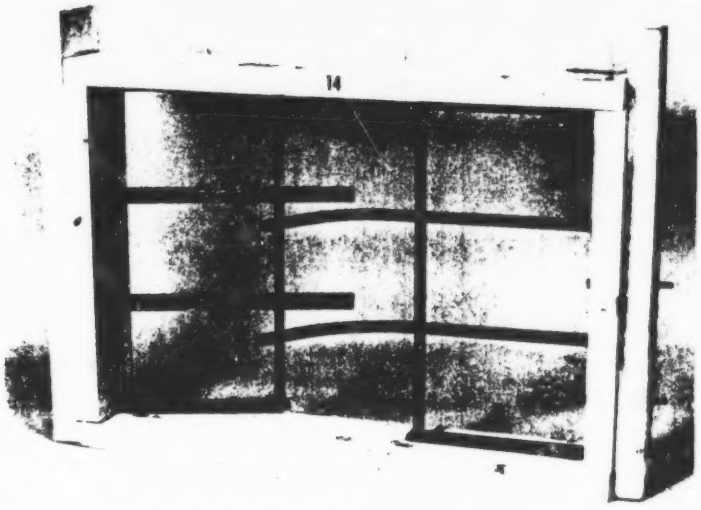


FIGURE 47. Window Guard #14 After the Straight Push Test

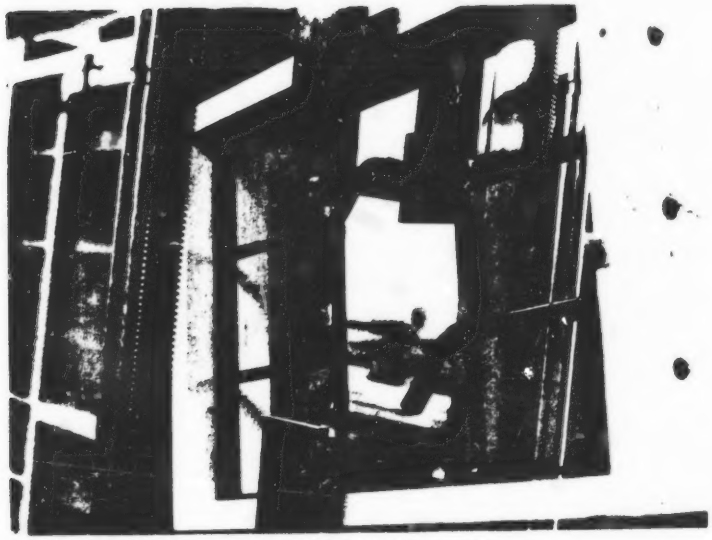


FIGURE 48. Window Guard #14 During the Bar Separation Test

RESULTS

The straight push test conducted by applying a load to the top horizontal bar components (at the center), caused the guard to fail at 4938 N (1110 lbs).

The two guard sections separated in the middle, after being pushed 191 mm (7½ in.) towards the inside, producing an opening large enough to allow entry. Figure 47 shows window guard #14 following test.

The bar spreading test conducted by applying a load between the two horizontal bars (at the center) increased the separation between bars from 133 mm (5¼ in.) to 330 mm (13 in.) at a load of 18,810 N (4229 lbs). The lower horizontal bar segments were separated from each other, while the top horizontal bar components remained united. Figure 48 and 49 show guard #14 during test and after test.

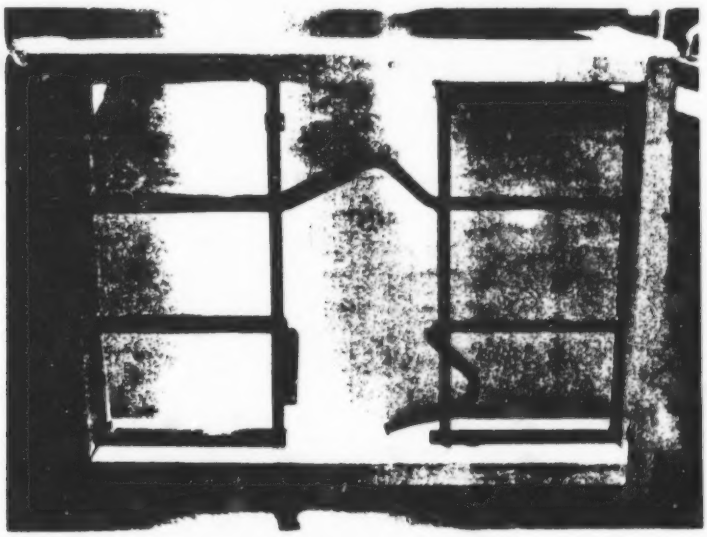
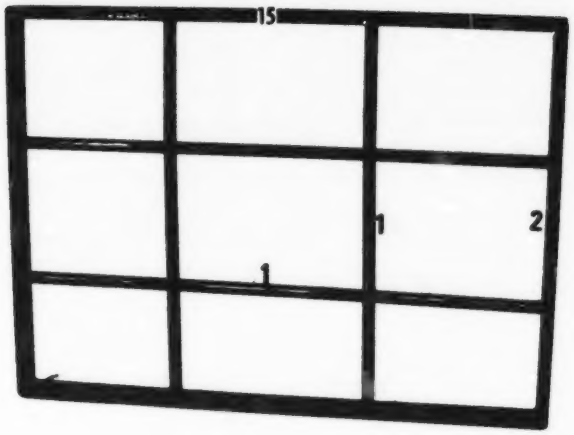


FIGURE 49. Window Guard #14 After the Bar Separation Test

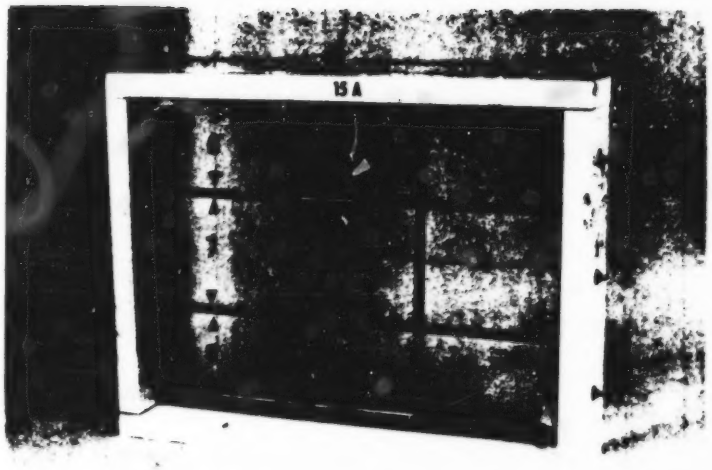
CONCLUSION

The test data showed that it is easier to gain entry through window guard #14, by pulling or pushing on one component of the guard, rather that by spreading two bars. A load of 4938 N (1110 lbs) was sufficient to produced the required opening size.



1) 12.5 mm ($\frac{1}{2}$ in.) diameter steel rods

2) 25 mm (1 in.) U-channel



3) 6.35 mm ($\frac{1}{4}$ in.) diameter bolts

4) 184 mm ($7\frac{1}{4}$ in.)

5) 191 mm ($7\frac{1}{2}$ in.)

6) 114 mm ($4\frac{1}{2}$ in.)

7) 146 mm ($5\frac{3}{4}$ in.)

8) 127 mm (5 in.)

9) 613 mm (24 1/8 in.)

10) 457 mm (18 in.)

FIGURE 50. Window Guard #15 Before Test

WINDOW GUARD #15

MATERIALS AND DESIGN

Window Guard #15 is a fixed guard, consisting of two horizontal 12.5 mm (½ in.) diameter steel rods, welded to the sides of a frame made of 25 mm (1 in.) U-channel, and two vertical steel rods bent around the horizontal rods and welded to the top and bottom of the metal frame. The rods are also welded at their intersection. Window guard #15 is shown in Figure 50.

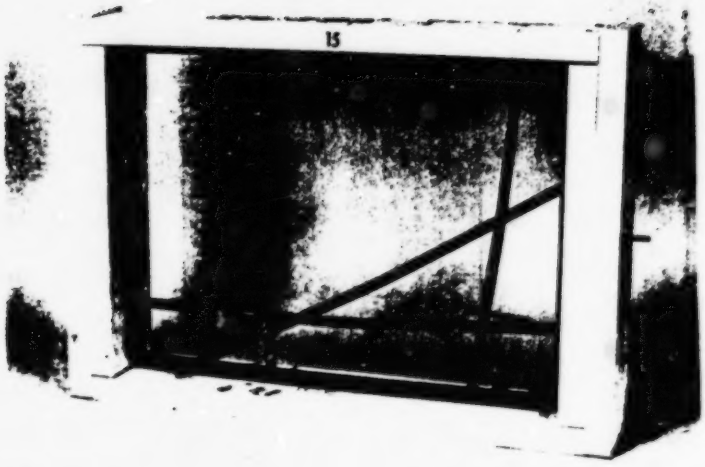


FIGURE 51. Window Guard #15 After the Straight Push Test

FIGURE 52. Window Guard #15 After the Bar Separation Test

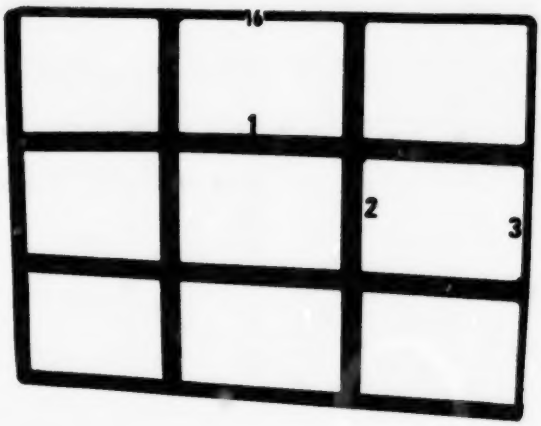
RESULTS

The results of the straight push test indicated that entry could be gained after two bars had been removed. The top horizontal bar, and the vertical bar located on the right side of the guard were removed at loads of 6450 N (1450 lbs), and 3158 N (710 lbs) respectively. Window guard #15 is shown in Figure 51.

The bar separation test conducted by applying a load between the horizontal bars, indicated that a load of 2340 N (526 lbs) was sufficient to create an opening large enough to allow entry. The separation between bars was increased from 146 mm (5¾ in.) to 241 mm (9½ in.). Window guard #15 is shown in Figure 52, following the spreading test.

CONCLUSION

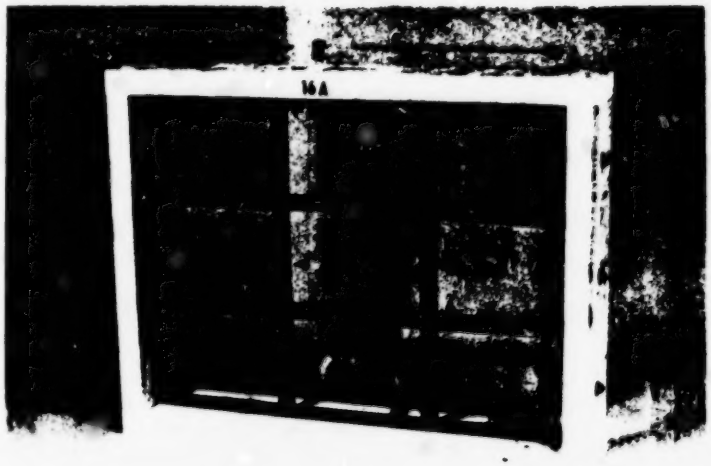
The test data indicated that it is much easier to gain entry through window guard #15, by spreading the bars rather then by pushing or pulling on components of the guard. A spreading force of 2340 N (526 lbs) was sufficient to produce the required opening size.



1) 22 mm (7/8 in.) diameter horizontal steel pipes (one piece)

2) Short steel pipe segments

3) 32 mm x 6.25 mm (1¼ in. x 44 in.) flat steel frame



4) 6.35 mm diameter (¼ in.) bolts

5) 178 mm (7 in.)

6) 191 mm (7½ in.)

7) 146 mm (5¾ in.)

8) 613 mm (24 1/8 in.)

9) 457 mm (18 in.)

FIGURE 53. Window Guard #16 Before Test

WINDOW GUARD #16

MATERIALS AND DESIGN

Window guard #16 is a fixed guard, consisting of two 22 mm (7/8 in.) diameter horizontal steel pipes welded to a 32 mm x 6.25 mm (1¼ in. x ¼ in.) flat steel frame; and six vertical steel pipe segments, positioned between the horizontal pipes and between the horizontal pipes and the metal frame (all pipe segments are welded). Window guard #16 is shown in Figure 53.

FIGURE 54. Window Guard #16 After the Straight Push Test

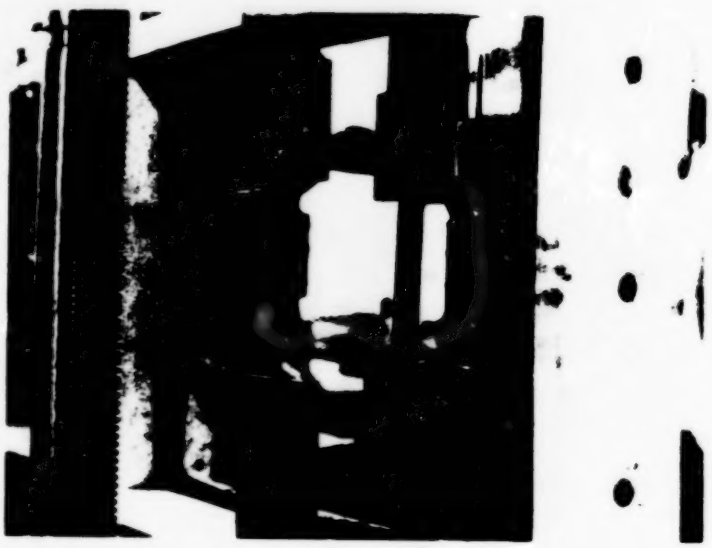


FIGURE 55. Window Guard #16 During the Bar Separation Test

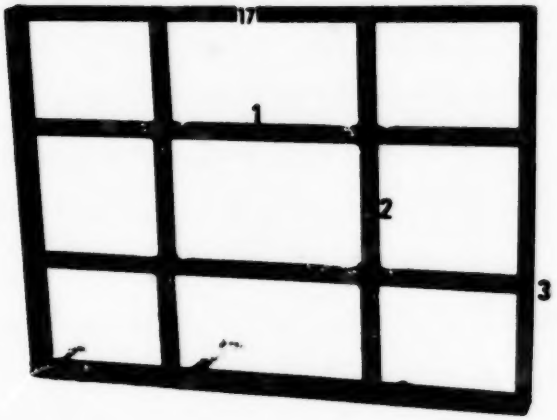
RESULTS

The results of the straight push test conducted by applying a load to the center of the top horizontal bar indicated that window guard #16 exceeds the maximum prescribed load of 17,793 N (4000 lbs). The horizontal bar was pushed in 99 mm (3.9 in.) from its original position, before the maximum prescribed load was reached. Window guard #16 is shown in Figure 54.

The bar separation test conducted by applying a load between the horizontal bars (at the center) led to a window frame failure at a load of 25,290 N (5,685 lbs); just short of the maximum prescribed load (26,690 N or 6000 lbs). One of the vertical bar segments was disjointed, but the guard was in otherwise sufficiently good condition to reach the maximum prescribed limit. The distance between the horizontal bars had been increased from 146 mm (5¾ in.) to 241 mm (9½ in.); however entry could not be gained, since the vertical bar segments restricted the opening size to a width of 191 mm (7½ in.). Figure 55, shows window guard #16 during test.

CONCLUSION

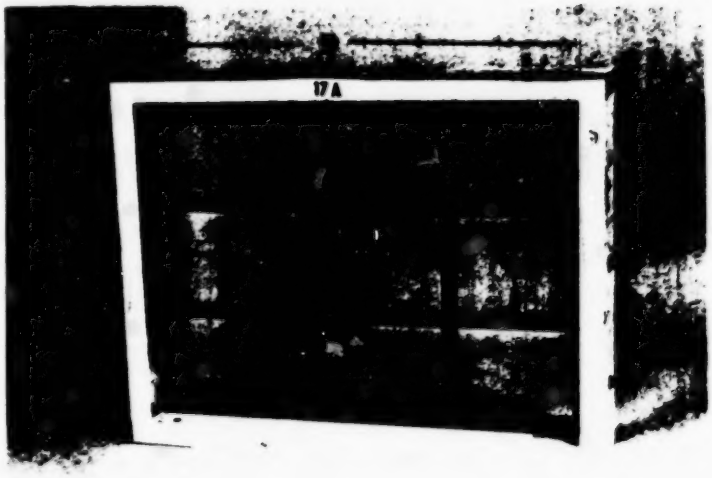
The test data showed that window guard #16 exceeded the maximum prescribed load for the straight push test. The data also indicated that the window guard would have likely reached the set maximum limit of the bar separation test, had the window frame not failed.



1) 19 mm ($\frac{3}{4}$ in.) diameter steel rods

2) 19 mm ($\frac{3}{4}$ in.) diameter steel rod segments

3) 32 mm x 3.2 mm ($1\frac{1}{4}$ in. x 1/8 in.) U-channel steel frame



4) 6.35 mm ($\frac{1}{4}$ in.) diameter bolts

5) 127 mm (5 in.)

6) 140 mm ($5\frac{1}{2}$ in.)

7) 165 mm ($6\frac{1}{2}$ in.)

8) 216 mm ($8\frac{1}{2}$ in.)

9) 610 mm (24 in.)

10) 460 mm (18 1/8 in.)

FIGURE 56. Window Guard #17 Before Test

WINDOW GUARD #17

MATERIALS AND DESIGN

Window Guard #17 is a fixed guard, consisting of two 19 mm ($\frac{3}{4}$ in.) diameter, horizontal steel rods, welded to a 32 mm x 3.2 mm ($1\frac{1}{4}$ in x 1/8 in) U-channel steel frame, and six vertical steel rod segments positioned between the horizontal rods and between the horizontal rods and the metal frame (all the segments are welded). Window Guard #17 is shown in Figure 56.

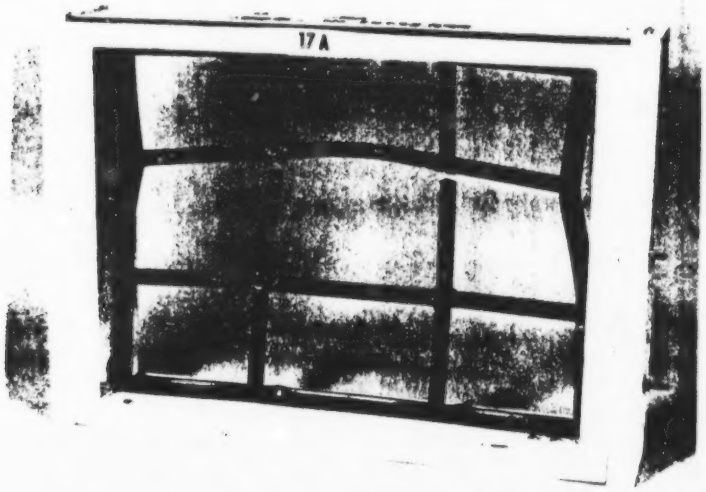


FIGURE 57. Window Guard #17 After the Straight Push Test

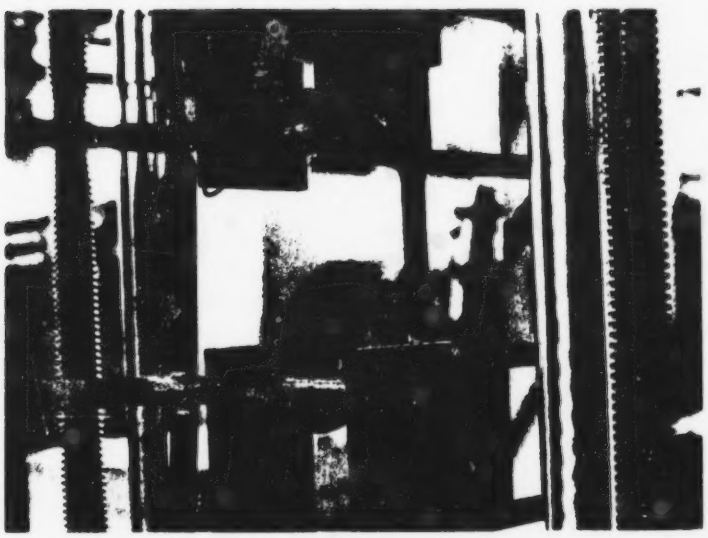


FIGURE 58. Window Guard #17 During the Bar Separation Test

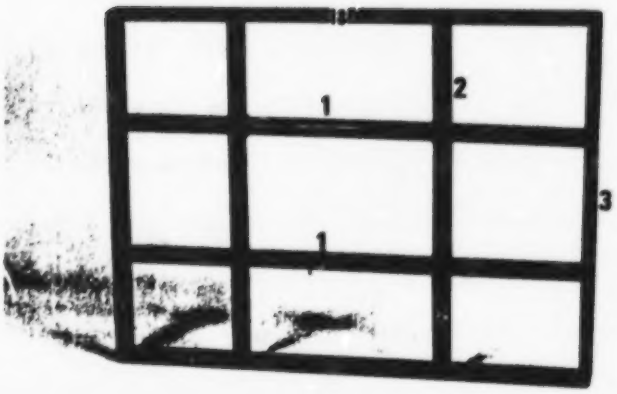
RESULTS

The results of the straight push test conducted at the center of the top horizontal bar, indicated that window guard #17 exceeds the set maximum prescribed load of 17.79 kN (4000 lbs), when tested in that direction. The guard reached the maximum load even after the weldings joining the top horizontal bar to the intermidiate bar segments had broken off. Figure 57 shows window guard #17 following test.

The results of the bar separation test, conducted by applying a load between the horizontal bars (at the center), indicated that window guard #17 also exceeds the maximum prescribed load for the spreading test (26.69 kN or 6000 lbs). Entry could not be gained even if the separation between bars had been increased to 210 mm (8¼ in.), since the vertical bars segments restricted the opening to a width of 216 mm (8½ in.). Figure 58 shows window guard #17 during the bar separation test.

CONCLUSION

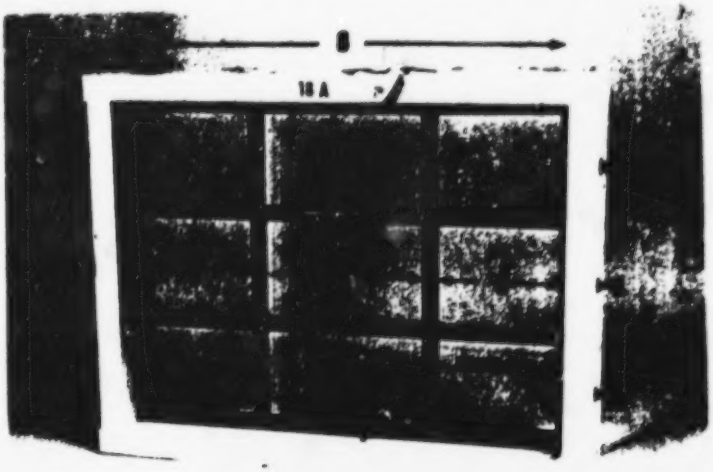
The test data indicated that window guard #17 exceeds the maximum prescribed loads for both the straight push test and bar separation test.



1) 22 mm (7/8 in.) diameter steel pipes, filled with 6.25 mm (¼ in.) steel cables

2) 22 mm (7/8 in.) diameter, steel pipe segments

3) 32 mm x 3.2 mm (1¼ in. x 1/8 in.) U-channel steel frame



4) 6.35 mm (¼ in.) diameter bolts

5) 162 mm (6 3/8 in.)

6) 216 mm (8½ in.)

7) 127 mm (5 in.)

8) 613 mm (24 1/8 in.)

9) 460 mm (18 1/8 in.)

FIGURE 59. Window Guard #18 Before Test

WINDOW GUARD #18

MATERIALS AND DESIGN

Window Guard #18 is a fixed guard, consisting of two 22 mm (7/8 in.) diameter, horizontal steel pipes, welded to a 32 mm U-channel steel frame; and six vertical steel pipe segments, positioned between the horizontal steel pipes, and between the horizontal steel pipes and the metal frame (all the segments are welded). This window guard is similar to window guard #16, except that the horizontal steel pipes are filled with 6.35 mm ($\frac{1}{4}$ in.) steel cables, to delay cutting with a hacksaw. Window guard #18 is shown in Figure 59.

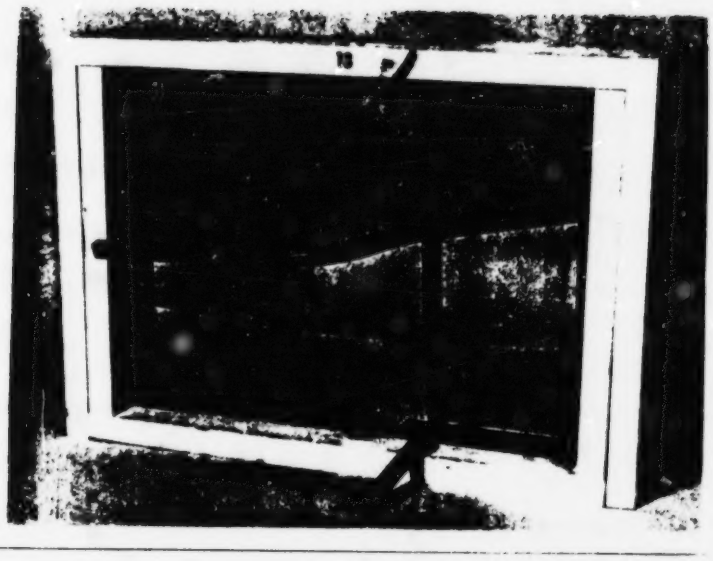


FIGURE 60. Window Guard #18 After the Straight Push Test

FIGURE 61. Window Guard #18 During the Bar Separation Test

RESULTS

The straight push test was conducted by applying a load to the center of the top horizontal bar, followed by the application of a second load to the same bar, but closer to the metal frame. As a result, the weldings, joining the two top vertical bar segments to the frame and the top horizontal bar as well as the weldings joining one end of the top horizontal bar to the frame, broke off, making it possible to push the top part of the guard to the point where entry could be gained. The loads reached 11,076 N (2490 lbs) and 4470 N (1005 lbs) respectively. Figure 60 shows window guard #18 following the straight push test.

The bar separation test was conducted by applying a force between the horizontal bars (at the center). Testing had to be discontinued at a load of 20.7 kN (4654 lbs), following failure of the window frame. There was no evidence that the guard would fail before reaching the maximum prescribed load, other than the fact that one end of a vertical bar segment joining the horizontal bars, had become disjointed under tension. Figure 61 shows guard #18 during test.

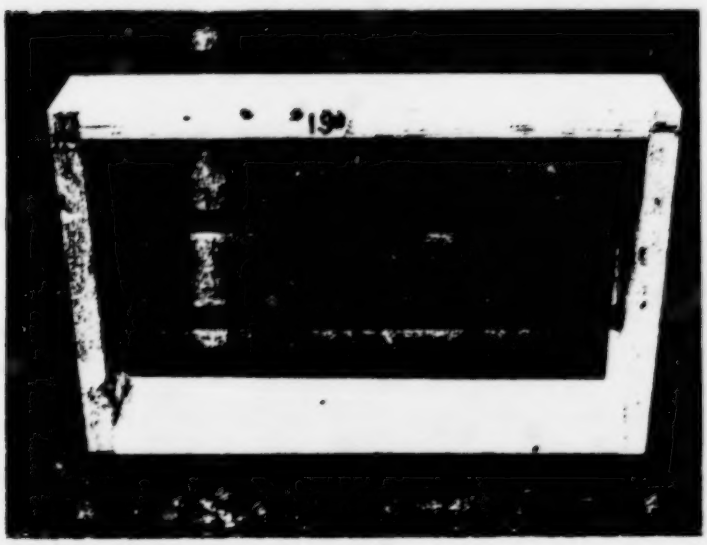
CONCLUSION

The data indicated that the window guard might have reached the maximum limit of the bar separation test, had the window frame not failed prematurely. However, the guard failed during the straight push test, after two load applications of 11076 N (2490 lbs) and 4470 N (1005 lbs) respectively.

WINDOW FRAME #19

MATERIALS AND DESIGN

Window Guard #19 consists of two lengths of 10 mm ($\frac{3}{8}$ in.) diameter, black iron pipe (water pipe) installed horizontally across a window frame. For home installation the pipes should be cut a minimum of 75 mm longer than the opening of the window frame. Holes are drilled completly through the wood frame and into the concrete. The bars should be predrilled on one end to receive a locking pin. The bar is then inserted into one side of the frame as far as it will go. Then it is pulled back into the other side of the frame, and a pin is inserted through a hole that has been drilled into the frame to meet the hole in the bar. Window guard #19 (without locking pins) is shown in Figure 62.



1) 19 mm ($\frac{3}{4}$ in.) diameter black iron pipe
2) 102 mm (4 in.) separation between bars
3) 108 mm ($4\frac{1}{4}$ in.)
4) 629 mm ($24\frac{3}{4}$ in.)
5) 381 mm (15 in.)

FIGURE 62. Window Guard #19 Before Test

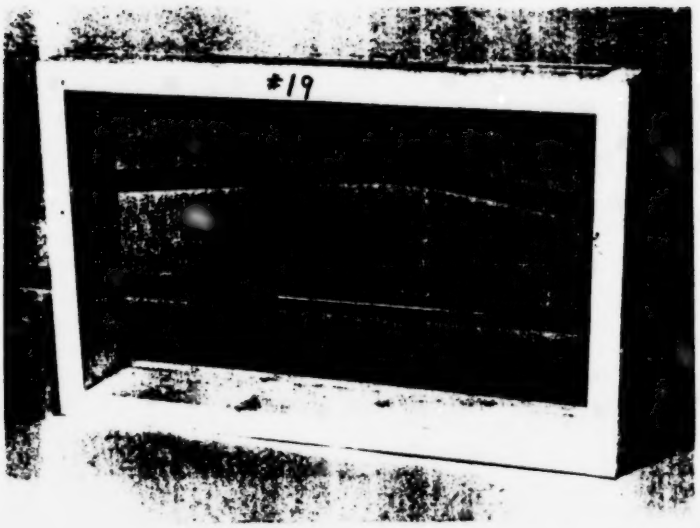


FIGURE 63. Window Guard #19 After the Straight Push Test
(Top bar was re-installed for photo)

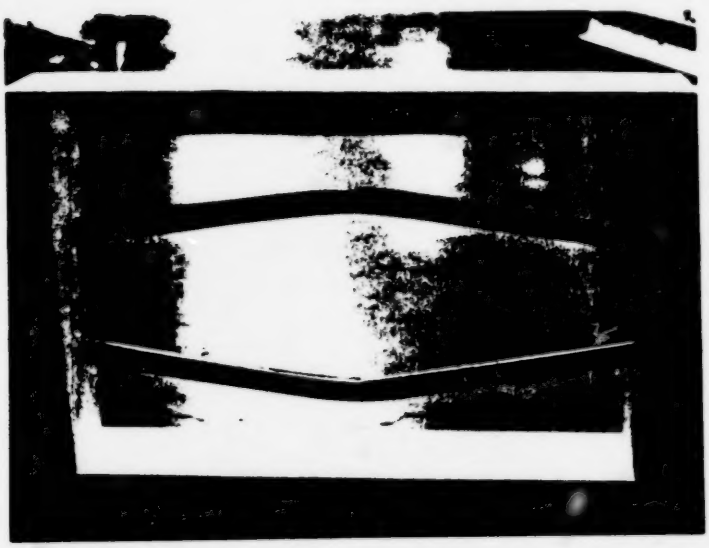


FIGURE 64. Window Guard #19 After the Bar Separation Test

RESULTS

The straight push test carried out by applying a load at the center of the top bar, indicated, that a load of 6681 N (1502 lbs) was required to remove the bar from the frame. The bar was pushed in 157 mm (6.2 in.) from its original position before it was freed from the frame. Figure 63 shows the bar at the point of failure.

The bar separation test results indicated that a force of 5130 N (1153 lbs) was required to produce an opening large enough to gain entry. The separation between bars was increased from 114 mm (4½ in.) to 191 mm (7½ in.) before the test was discontinued. Figure 64 shows window guard #19 following the bar separation test.

CONCLUSION

The test data indicated that a spreading force of 5130 N (1153 lbs) was required to gain entry through guard #19, while a load of 6681 N (1502 lbs) was needed using the straight push method.

POOR

QUALITY

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